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ABSTRACT

This document is the result of an effort to develop a comprehensive curriculum to train community college students as energy management technicians. The main body of the document contains the energy management technician training curriculum and course content for the proposed courses in the two-year sequence; a report of how the curriculum was developed and evaluated makes up the rest of the document. The curriculum addresses the following needs: updating technical skills for design and review of energy systems; acquiring familiarity with historical approaches and current technologies for energy conversion and use; developing management abilities; and learning how to establish a viable energy management organization. Content areas covered in the curriculum include an introduction to energy issues and policies, materials and design in conservation, solar energy concepts, advanced solar energy concepts, renewable energy systems, fundamentals of heat transfer, energy usage of commercial buildings, energy auditing/calculations, energy control devices, energy building codes, updating seminars, and on-the-job training. Each course description contains student objectives and characteristics, teaching methodology, supplemental instructional materials, and films and reference sources. (KC)

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ED199462

ENERGY MANAGEMENT TECHNICIAN
CURRICULUM DEVELOPMENT

FINAL REPORT
Project No. 79-AHV(221)NP

Curriculum Development Project
Conducted Under
Public Law 94-482

The project reported herein was performed pursuant to a grant from the Research Coordinating Unit of the Washington State Commission for Vocational Education. Contractors undertaking such projects under the Commission for Vocational Education sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Commission for Vocational Education position or policy.

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TABLE OF CONTENTS

Summary of the Report	1-3
The Report	4-12
Acknowledgments	4
State of the Problem	5
Methodology/Schedule of Project	6
Conclusions and Recommendations	11

Appendices

- A - College Catalog Information
- B - Degree Requirements
- C - Course Syllabi/Instructional Materials
- D - Enrollment Data 1979-80
- E - Course Offerings 1980-81
- F - Promotional Literature
- G - Employer Survey compiled October 1980
- H - Ad-Hoc Advisory Committee Composition
- I - Northwest Energy Management Education Consortium
- J - Resources

- Higher Education
- Governmental
- Professional Organizations & Interest Groups
- Funding
- Audiovisual

K - Bibliography

- Researched for Project
- Edmonds CC Library/Media Center

SUMMARY OF THE REPORT

SUMMARY OF THE REPORT

A. Time period

The time period covered by this report was twelve months, from June 1, 1979 through May 31, 1980. Later, the contract was extended to August 30, 1980, a total period of fifteen months.

B. Goals and Objectives of the Program

The goals and objectives of the project are as stated in the proposal. The major objective of this grant sought to develop comprehensive curriculum where none presently existed to train students as energy management technicians. This objective was achieved by the attainment of the following sub-objectives: 1) Research pertinent materials for assessment by staff and expert advisors by July 15, 1979. 2) Adopt work plan to identify topic inclusions and course descriptions by September 15, 1979. 3) Develop syllabi and integrate into program sequency by October 1, 1979. 4) Field test tentative curriculum with 25 students by May 15, 1980. 5) Evaluate each step within each phase by impaneling expert advisors, and by student and faculty course and program evaluations by May 15, 1980. 6) Assimilate supplemental instruction materials, develop guidelines, publish and submit with final curriculum adoption to RCU by May 13, 1980 (later extended to August 30, 1980).

C. Procedures

The research design team was comprised of qualified staff, faculty and field consultants which assembled contributions from related fields and training packages, examined these in consort with a panel of industrial and educational experts (ad-hoc advisory committee), constructed course syllabi for non-existent courses and field tested curriculum during the 1979-80 school year. Each field-tested course was evaluated continuously by expert advisors and all courses taught were scrutinized through standardized course evaluative techniques by students and faculty.

D. Results

The Energy Management program, as developed by this project, is designed to graduate technicians who can work in the field of energy utilization, consumption and conservation. The graduate will be able to obtain employment in any one of the following fields: energy-related research and development, auditing energy consumption, energy use management of commercial buildings, working for specialized energy conservation firms, and the development of energy efficient construction practices including design and installation of solar or alternative heating systems.

The program addresses the need for: updating technical skills for design and review of energy systems; acquiring familiarity with historical approaches and current technologies for energy conversion and use; develop-

ing management abilities, and learning how to establish a viable energy management organization.

Curriculum inclusions address: an introduction to energy issues and policies, materials and design in conservation, solar energy concepts, advanced solar energy concepts, renewable energy systems, fundamentals of heat transfer, energy usage of commercial buildings, energy auditing/calculations, energy control devices, energy building codes, updating seminars, and on-the-job training.

The project, as performed, enabled Edmonds Community College to: develop the curriculum content for a two-year Associate of Technical Arts degree in Energy Management training; develop course syllabi for energy core classes; identify instructional resource aids, agencies and possible personnel/faculty; and produce a compendium curriculum guide for replication for use by other community colleges, that will train students as energy management technicians.

E. Evaluation

A panel of experts (faculty, staff, administration and ad-hoc advisory committee) evaluated the course content and decisions related to resources, employer needs and the like. This technique was utilized in each step of the project and particularly, with respect to the nearing of completion towards achievement of objectives and goals.

Qualitative evaluations were conducted through student and faculty evaluations of each course given in the field test phase. Standard course content and procedures evaluative instruments were utilized as are applied in other courses at Edmonds Community College.

Quantitative evaluation will become a self-testing process resulting from a follow-up of program evaluation through graduates who will be obtaining employment in the field. Although the curriculum development project itself concluded prior to the actual completion of training, the college is committed to undertake an initial and continuing follow-up study of training components. Consequently, an up-date supplementary evaluation report will be available by 1983.

F. Conclusions and Recommendations

Upon thorough evaluation of the project, several types of student groups/objectives were identified. Student motivations and interests were determined in two broad categories - vocational preparatory and occupational supplementary. In addition, it was also found that there were important differences in student backgrounds and competencies prior to entering the program or a given course. In particular, this was evident in the abilities to perform problem-solving and calculation problems.

In conclusion, curriculum direction is an important factor to consider before an institution commits itself to an energy education program. Local needs or "program thrusts" must be identified early-on to provide the immediate community with the necessary training.

The diversities of student objectives and preparation imply that many unanswered questions will be responded to only in time. It further implies that the curriculum guide, as developed herein, is by no way complete or final. However, it can be stated that the curriculum developed for this project is the beginning to a continued refinement of energy curricula.

THE REPORT

Acknowledgements

Our sincere appreciation is truly in order to those who gave of their time and efforts to contribute to the success of this project.

In the community college system, acknowledgement of the part-time instructor often goes unnoticed and unrewarded. Our gratitude goes to Mr. Perry Lovelace and Mr. Joseph Weinstein, both of Seattle, Washington. Not only must we give thanks to these two gentlemen for their cooperation and support on this curriculum development project, but also, for their original endeavors several years ago when they came to us foreseeing a need to train people in the energy management field. It is truly rare to find such individuals with extensive expertise in the energy management field, as well as superb backgrounds in curriculum development.

Notwithstanding, our thanks goes to the following individuals who served on the ad-hoc advisory committee and as technical consultants throughout the project's duration:

Michael Blackmon, Technical Education Research Center, Waco, Texas
Jim Bruvold, Bouillon, Christofferson and Schairer
Terry Dolan, Region 10, U.S. Department of Energy
Dean Hardy, Naramore, Bain, Brady & Johnson, Architects
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Bruce Lampcov, private Energy Management Consultant
Don Tranum, Department of Transportation
Carol Costello, Washington State Energy Office
Jim Scace, Energard

And, last, but not least, Thomas C. Nielsen, President of Edmonds Community College and Grahame Bell, Chairman, Board of Trustees, District 5, Washington State Community College System. Without their continued support, understanding, and guidance, the results would be meaningless.

Statement of the Problem

With the formation of the United States Department of Energy and numerous state and local agencies such as: Washington Energy Office; Washington Energy Extension Service; Seattle Energy Office; plus local public and private utility companies forming new energy departments, the public awareness for energy conservation and alternative uses has created a demand for the Energy Management Technician. This is apparent by the dearth of evidence of on-going comprehensive studies on energy related generation in the nation.

The federal government, by passing the "National Energy Act", mandates that funds be made available to perform energy audits of federal and state public buildings, including schools and hospitals. Along with the audits, the government is going to be funding the expense of retrofitting existing public buildings to cut down on energy consumption. The "Act" will also mandate audits to be performed, but fails to provide the means for training auditors.

Industry and labor alike passed along to the Washington State vocational directors the need to expand occupational training for existing employees and preparatory training for an emerging, expanding occupation in energy management. The community college administrators, in response to industry demands, launched an immediate assessment of these suggested needs.

In 1977, Northwest Energy Management Education Consortium (NEMEC) was established by the Vocational Directors Council and coordinated by the staff of the State Board for Community College Education. Edmonds Community College, along with four other two-year colleges in the state, was an integral part of the consortium from the onset to initiate a statewide need survey for energy management technicians, employment trends, and training standards.

A statewide survey unveiled a greater need for energy management technicians in utilities, and a growing need in manufacturing firms. Nearly 60% of employers responding were seeking or had assigned personnel to perform energy-related tasks. The study indicated that most of these people had little or no specific training in this area. Engineering-related firms reported a small number of technicians hired. Most employers in all categories indicated an interest for the community colleges to initiate training. It is however, important to point out, that most employers indicated that employment in the energy management field would be quite dependent on energy availability and costs, governmental controls, and the supply of qualified energy management personnel.

In this survey, energy related roles were well identified by industry as a "new and emerging work force need and job opportunity". Based upon this input from Washington state's industrial voice, Edmonds Community College, with funding support by the Washington State Commission for Vocational Education, embarked on the development of a comprehensive curriculum designed to train technicians in the field of energy management.

Methodology/Schedule of Project

In beginning this project, a methodology or schedule had to be established in order that a systematic approach to the problem could be addressed. The following is a synopsis of the critical path schedule utilized in accomplishing the task:

The first objective was to identify and select the necessary personnel to work on the project. Of great concern was the location of personnel with both expertise in the energy management field and curriculum development. Further, college staff and faculty were needed with management and organizational skills that also knew the college procedures and policies regarding new program adoption, instructional analysis and evaluative skills. This management team set the stage for a unified effort towards the project's objectives and included: Elaine (Miller) Weitz as Project Director, Dr. Robert Sarvis, Project Investigator, Mr. Perry Lovelace and Mr. Joseph Weinstein, part-time faculty.

In June, 1979, the management team met to discuss the project's goals and objectives. It was apparent that expert advisors from industry and government would be needed for constant feedback and concurrence of the work about to be undertaken. Adequate spread of industry representation was imperative to ensure that all facets of concerns and needs would be addressed in the curriculum. Governmental agencies including the Washington State Energy Office, Washington Energy Extension Service, U.S. Department of Energy were contacted. Industry representation was requested from architectural/engineering firms, large manufacturers including Boeing Commercial Aircraft Co., Weyerhaeuser, construction firms, energy management consulting firms and private/public utilities. Even from the initial request, interest and support was overwhelming.

With the formation of an advisory committee comprised of technical advisors, research of related curricula for pertinent material that would prove useful in establishing a total energy management curriculum was ready to begin.

Curricula literature abounds with works pertaining to the technical aspects of engineering and the building trades, but little emphasis has been accorded the interdisciplinary requirements of energy management. One component, solar energy, has merited recent attention nationally, and teaching units now exist on the principles and construction of passive and active system construction. For example, correspondence course syllabi from the National Association of Sheet Metal and Air Conditioning Contractors, Vienna, VA, for Department of Energy, 1978, treats the fundamentals of solar heat. Colorado State University offers research training materials for graduate engineers studying residential solar system design, construction, and operation. In-depth lectures are provided to stimulate and support basic research efforts, and some of these notes proved useful for this curriculum development grant. Scott Community College in Bettendorf, IA, have developed related materials for teaching solar fundamentals in their air conditioning and refrigeration technician training program.

Technical Education Research Center in Waco, TX, has concentrated on nuclear technology technical training materials. This private research/consulting firm is further engaged in the production of additional modules to incorporate solar fundamental education. The modules are scheduled under a Department of Energy contract to become available sometime in 1982-83 and could prove valuable as partial content for an alternative teaching mode in the mid-eighties.

Regardless of the development efforts beginning in specialized curricular areas, no work is known to exist that borrows from these intensive studies to satisfy the curricular needs for training at the technician level. Further, none appear to consider the comprehensive scope that is required to assure training for a more general energy use knowledge by the energy management technician.

Before final selection of courses could be identified as inclusions in the Energy Management program, Energy Management had to be defined. The following working definition was subsequently developed:

"Energy Management is the development and implementation of a systematic energy management process. Included in the management procedures, would be: reporting and auditing energy usage; development of operating plans and conservation guidelines; the monitoring and improvement of the energy management system on an on-going basis; continued assessment of benefits realized from sound energy management practices."

Further, four major areas of energy related occupations were categorized. With future advancement of technologies, other areas will be defined and added to the list. Those four areas include: Energy Conservation; Energy Management; Solar Technology; and Alternative Energy.

Energy Conservation - involves the development of a basic knowledge and understanding of the application of energy conservation techniques, competence in determining excess energy usage, and designing conservation strategies to curtail energy consumption. These would include insulation, weatherization, infiltration and equipment utilization for maximum energy efficiency and greatest savings.

Energy Management - would concentrate on the development and implementation of a systematic energy management process. Areas to be included are energy management procedures, reporting and auditing energy use, and developing operating plans and conservation guidelines. Also included would be the capability to monitor and improve the energy management system on an on-going basis and to assess benefits realized from sound energy management practices.

Solar Technology - develops a basic understanding of solar energy concepts including solar heating and cooling, an understanding of active and passive solar systems with emphasis on system design, economics and cost-benefit analysis.

Alternative Energy - covers familiarization with various alternate energy sources and the application of these in a practical way. Possible sources to be further studied would include solar, wind, biogas, and water; with emphasis on developing and understanding of the relationship between fossil fuels and alternate energy sources and their potential co-utilization.

The graduate Technician would be able to be employed in any of the following energy fields:

- * energy-related research and development
- * auditing energy consumption
- * energy use management of commercial buildings
- * working for specialized energy conservation firms
- * energy efficient construction which may include designing and installing solar or other alternate heating systems
- * distributor for manufacturers selling energy systems

The defined responsibilities and functions of the Energy Management Technician might include:

- * an ability, knowledge and skill to test, operate, maintain, or install/modify equipment used in homes, businesses, institutions and factories
- * analyze the production, use or conservation of energy
- * recommend and follow-through on steps required to increase the efficiency in the use of energy

Typically, the technician can apply modern sophisticated testing equipment to systems using combinations of mechanical, electrical, thermal, fluid, and/or optical components in energy research, production, use of conservation. Frequently these systems are controlled by electronic computers or micro-processors. The technician usually works under the direction of an engineer, scientist, or manager, often with a large degree of independence, and often supervises the efforts of skilled workers in accomplishing the tasks necessary to the position.

To define curriculum, topic inclusions, prerequisite skills levels, length of training, the type of student to be served, and what the student's backgrounds would be, had to be defined. Because of the high interest being generated by governmental regulations, controls and mandates on available energies, and coverage of such by local news media, a wide variety of expertise and skill levels of students entering the program were anticipated. With this assumption, it was expected that some students would have no prior knowledge of energy use and consumption, others with limited and/or specialized construction trade skills, and others with engineering or architectural background looking to upgrade their existing skills. Because of the highly complex skills required for such training, it was assumed that students entering the program would have a basic understanding of algebra and physics concepts, or previous experience in energy systems operations, installation or maintenance.

Identification of areas or topics that the student would have to be knowledgeable in prior to graduating from the program was established. Those include an understanding of:

- economics
- communication and speech skills
- management skills
- technical writing skills
- computer programming
- accounting skills for measuring pay-back periods for retrofit
- thorough understanding of blueprints
- building codes - how building code regulations affect new and remodel construction including new energy codes
- basic concepts of physics; in particular, practical thermodynamics
- basic electricity and electronic devices
- construction materials
- mechanical and electrical systems used in buildings
 - including heating, ventilation, and air conditioning
- basic drafting skills
- the history of energy and its role on the economy
- materials and design in conservation
- energy control systems and devices

renewable energy systems (including solar, wind, water, biogas, etc)
lighting and acoustics
ac/dc circuits
energy auditing/calculations
the application and control of energy systems in commercial buildings

Based upon the assumptions gathered above, the project team proceeded to identify and review existing courses on campus for appropriateness of content to avoid possible duplications of course offerings. Meetings were set up with other related programs to discuss existing courses and content, to explain the energy management program; its goals and objectives, and to determine whether or not existing courses could meet the needs of prospective students.

Several existing courses had already incorporated energy topics and issues into the course offerings, where others agreed to include these areas into future offerings. Those being:

Econ 201	Principles of Economics
Phys 140	Concepts of Physics
Math 80	Fundamentals of Algebra
Const 120	Introduction to Commercial & Residential Const.
Const 141	Blueprint Reading
Const 170	Introduction to Mechanical Systems
Const 175	Introduction to Electrical Systems
Eltrn 115	Basic AC/DC Circuits
Spch 100	Fundamentals of Speech
Engl 111	Technical Report Writing
Trans 100	Introduction to Transportation
Draft 101	Architectural Technical Drawing
Math 115	Introduction to Computer Programming

Upon completion of the above tasks, the project team and ad-hoc advisory committee were then able to identify curriculum voids in the following areas:

Introduction to Energy - the history, present and possible futures
Materials and design in conservation
Solar energy concepts
Renewable energy systems
Practical thermodynamics - fundamentals of heat transfer
Energy control devices and systems
Energy auditing/calculations (both at the residential and commercial levels)
Lighting and acoustics
Independent study and research
On-the-job training (Cooperative Education)
Specialized seminar/workshop learning experiences

The duration of the project sought to develop these identified curriculum voids into course modules, to field test as many of these modules as time permitted, and to arrive at a complete training package.

Six of the eleven courses identified on the previous page were field-tested during the 1979-80 school year:

- Energy 100 - Introduction to Energy
- Energy 110 - Materials and Design in Conservation
- Energy 130 - Solar Energy Concepts
- Energy 140 - Renewable Energy Systems
- Energy 150 - Fundamentals of Heat Transfer
- Energy 210 - Energy Auditing/Calculations

The remaining courses will be field-tested during the 1980-81 school year:

- Energy 211 - Commercial Buildings
- Energy 220 - Energy Control Devices
- Energy 230 - Advanced Solar Energy
- Energy 285 - Energy Building Codes
- Energy 155 - Energy Updating Seminars
- Energy 292 & 293 - Cooperative Education

The appended several pages outline course curriculum developed by the project team. With each field-tested course, additional materials are provided that include: student objectives and characteristics, teaching methodology, supplemental instructional materials, and films and reference resources. Further, it is important to realize that these materials are, by no means, in final form. That is, curriculum will continue to be refined based upon further course offerings and student input.

Conclusions and Recommendations

The project team's experiences throughout the duration of the project indicate a high demand for the Energy Management Technician. In addition, a variety of industries strongly support the concept of energy education at the community college level and report the need for such training has been in existence for some time. As a result, the industry consultants and ad-hoc advisory committee were extremely helpful in the development of curricula. Their expert guidance allowed incorporation of topics and concepts that could have been overlooked otherwise.

Upon thorough evaluation of student motivations and interests, several combinations of student groups/objectives were identified. Those include:

1. Students with a broader interest, more career-oriented or experienced in the construction industry.
2. Students oriented toward energy management of buildings.
3. Students oriented toward or in some engineering discipline concerned with energy use.
4. Students oriented toward or in governmental or policy work concerned with energy.
5. Students oriented toward or in business, manufacturing, or installation of energy equipment including energy controls, solar equipment, etc.
6. Students interested in "self-reliance" in order to construct their own energy-efficient dwellings or retrofitting existing structures for energy efficiency.
7. Students interested in learning about energy and energy problems as part of their overall educational background.

Note that most categories on this list -- 1 through 5 -- relate to the present or prospective vocation of the student, but that the other two categories -- 6 and 7 -- may well account for a much larger number of students. The curriculum has been devised to account for students whose motivation is "vocational", but several courses in it have wide appeal -- and probably draw many, and could draw many more, students whose motivation is simply "educational" or for "personal enrichment". With this in mind, it would be important that colleges contemplating an energy program consider two types of course offerings - "vocational preparatory" and "occupational supplementary or community service-type courses".

Besides the differences in student motivations and interests, it was also found that there were important differences in student backgrounds and competencies prior to entering the program or a given course. In particular, this was evident in the abilities to perform problem-solving

and calculation problems. Although prerequisites or equivalent experience levels were identified for each course, it became quite apparent that some students were able, others had the necessary training but were quite "rusty", others were potentially capable but lacked the necessary prerequisite training, and finally some students -- with or without formally meeting prerequisites -- simply lacked the needed combination of ability and motivation.

The above diversities of student objectives and preparation imply that many unanswered questions will be responded to only in time. It further implies that the curriculum guide, as developed, is by no way complete or final. However, it can be stated that the curriculum developed for this grant is the beginning to a continued refinement of energy curricula.

APPENDICES

ENERGY MANAGEMENT PROGRAM

The Energy Management program satisfies the need to train people to fill management and technical positions with responsibilities in energy supply, use, conservation . . . the entire spectrum of energy management. Taught at a technically appropriate level, these people will receive in-depth, relevant training. This program was designed to meet the needs of building and maintaining an effective energy management staff. There are few technical managers with the experience to handle such a broad range of responsibilities and coordinate the efforts of diverse division heads for whom energy is but a small concern.

Energy Management is a rapidly developing field with a need for qualified people in all phases of energy conservation, consumption and management. The Energy Management program is designed to graduate technicians who can work in the field of energy utilization, consumption and conservation. The purpose of the program is to fulfill a variety of needs. The graduate will be able to obtain employment in any one of the following fields: energy-related research and development, auditing energy consumption, energy use management of commercial buildings, working for specialized energy conservation firms, and the development of energy efficient construction practices including design and installation of solar or alternative heating systems.

The responsibilities and functions of such a technician might include providing direct support to engineers/architects; performing building "operating engineer" services (operations maintenance of building HVAC, electrical and mechanical systems); performing systems operational tests and analyses; performing energy-use audits, and performing energy conservation technical services related to construction, retrofits and system design; personnel supervision and management.

The faculty is composed of practicing energy managers and energy consultants to assure that the coverage of these topics is relevant to the needs of students.

Students can be pretested in algebra and pass with an acceptable score before acceptance into the program. This test is administered and proctored by the program coordinator or the counseling center. Other recommended proficiencies in basic physics and chemistry concepts would be helpful. The college accepts applications all year for admission to the program.

CURRICULUM

Students working toward an Associate of Technical Arts degree follow an integrated and well-balanced course sequence aimed at preparing them to step into responsible, well-paying positions as energy managers. The Energy Management program features a complete, continuing series of courses spanning all aspects of the subject. These courses address the need for:

- updating technical skills for design and review of energy systems;
- acquiring familiarity with historical approaches and current technologies for energy conversion and use;
- developing management abilities;
- learning how to establish a viable energy management organization.

Continuing course revisions and updates incorporating changing conditions, government regulations and new technologies prepare participants in the Energy Management courses for the challenges to today's world. Presentations, handouts, and texts are continually updated to meet the needs expressed by industry employers.

ASSOCIATE OF TECHNICAL ARTS DEGREE

An ATA degree in Energy Management is awarded upon completion of the Energy Management Certificate, and additional course work. 95 credits of approved course work is required for the ATA degree: 47 credits of technical courses; 35 credits of general requirement courses; 10 credits of electives; 3 credits of PE/Health.

TECHNICAL COURSES — 47 Credits Required

	Credits
ENRGY 100 Introduction to Energy	5
ENRGY 110 Materials & Design in Conservation	3
ENRGY 130 Solar Energy Concepts	3
ENRGY 140 Renewable Energy Systems	3
ENRGY 150 Fundamentals of Heat Transfer	5
ELTRN 115 AC-DC Circuits	4
ENRGY 210 Energy Auditing/Calculations	5
ENRGY 211 Commercial Buildings	5
ENRGY 220 Energy Control Systems	3
ENRGY 230 Advanced Solar Energy Concepts	3
ENRGY 285 Energy Building Codes	3
ENRGY 299 Special Projects/Selected Topics	5
	47

COLLEGE REQUIREMENT — 3 Credits Required

PE/HLTH 105 3

GENERAL REQUIREMENT — 35 Credits Required

ACCT 110 or 201	3-5
ECON 201 Principles of Economics	5
ENGL 111 Technical Report Writing	5
MATH 115 Computer Programming	5
CONST 120 Intro. to Construction (C&R)	3-5
CONST 141 Blueprint Reading — I	4
CONST 170 Intro. to Mechanical Systems	3
CONST 175 Intro. to Electrical Systems	3
CONST 280 Building Codes — I	3
	35

ELECTIVES — 10 Credits Required

Elective courses can be selected from the following list or programs or others as approved by coordinator.

Speech	Transportation
Data Processing	Physics
Construction	Chemistry
Electronics	

PLANNING SHEET

ENERGY MANAGEMENT PROGRAM
ASSOCIATE OF TECHNICAL ARTS DEGREE

EDMONDS COMMUNITY COLLEGE

STUDENT NAME _____ DATE/PLANNING SESSION _____ ADVISOR _____

STUDENT I.D. # _____ HOME _____ WORK _____

PROGRAM DESCRIPTION: The Energy Management program satisfies the need to train people to fill management and technical positions with responsibilities in energy supply, use, conservation...the entire spectrum of energy management.

ATA REQUIREMENTS: To acquire the ATA degree in Energy Management, the student must complete 47 credits from the energy technical core classes, 35 credits of general requirement courses, 10 credits of electives and 3 credits of Health/PE. 24 residency credits are required for graduation. One quarter prior to completion, students should complete a Diploma Application.

TECHNICAL COURSES (47 credits required)

COURSE	QTR	CR	GRADE
Enrgy 100 Introduction to Energy		5	
Enrgy 110 Materials & Design in Conservation		3	
Enrgy 130 Solar Energy Concepts		3	
Enrgy 140 Renewable Energy Systems		3	
Enrgy 150 Fundamentals of Heat Transfer		5	
Enrgy 210 Energy Auditing/Calculations		5	
Enrgy 211 Commercial Buildings		5	
Enrgy 220 Energy Control Systems		3	
Enrgy 230 Advanced Solar Energy Concepts		3	
Enrgy 285 Energy Building Codes		3	
Enrgy 299 Special Projects/Selected Topics		1-15	
Enrgy 191 Energy Co-op Seminar		1-3	
Enrgy 192 Cooperative Education		1-15	
Elect 115 AC/DC Circuits		4	

COLLEGE REQUIREMENT (3 credits required)

COURSE	QTR	CR	GRADE
Health 105 First Aid & Safety or PE		3	

GENERAL REQUIREMENT COURSES (35 credits required)

COURSE	QTR	CR	GRADE
Econ 201 Principles of Economics		5	
Engl 111 Technical Writing		5	
Math 115 Computer Programming		5	
Const 120 Introduction to Construction (C&R)		3	
Const 141 Blueprint Reading - I		4	
Const 170 Introduction to Mechanical Systems		3	
Const 175 Introduction to Electrical Systems		3	
Const 280 Building Codes - I		3	
Acct 201 Introduction to Accounting		5	

Elective courses can be selected from the following courses or others as approved by program coordinator.

ELECTIVE COURSES (10 credits required)

COURSE	QTR	CR	GR
Const 110 Architectural & Struc. Design		3	
Const 121 Sidewalk Superintendent		2	
Const 142 Blueprint Reading - II		4	
Const 160 Construction Materials		3	
DP 100 Intro. to Data Processing		3	
Elect 107-9 Basic Electricity & Electronic Devices		4-12	
Phys 140 Concepts of Physics		5	
Spch 100 Fundamentals of Speech		5	
Spch 120 Public Speaking		5	
Trans 101 Intro to Transportation		3	
Trans 104 Materials, Term, Warehouse Mgmt		5	
Trans 106 Physical Distribution		5	
Trans 201 Transportation Economics		5	
Previous Work Experience		10	

APPROVED TRANSFER CREDITS, COMPANY TRAINING, OR SPECIALIZED WORK EXPERIENCE CREDITS

DATE	ORGANIZATION/INSTITUTION	EXPLANATION	HOURS	CREDITS

Modifications can be made upon written approval of the program coordinator.

Technical Courses
General Courses
Elective Credits
Health/PE Requirement
TOTAL

EDMONDS COMMUNITY COLLEGE
ENERGY MANAGEMENT PROGRAM
TECHNICAL COURSE DESCRIPTIONS

ENRGY 100 - INTRODUCTION TO ENERGY (5 credits)

This course will cover the history of energy use and the development of the energy crisis. Topics to be covered will include: application of appropriate technology; energy concepts and terminology; alternative futures; useful forms of energy (renewable and non-renewable); solar space heating at the residential level; conservation and generation. In addition, field trips will be incorporated to orient the student to energy principles. Prerequisite: None

ENRGY 110 - MATERIALS AND DESIGN IN CONSERVATION (3 credits)

How to design and build an effective energy envelope including; design strategies and innovations for new construction, devices and alternatives for energy use in existing buildings, materials used in conservation and how to use them properly, such as; insulation types, windows, control devices, vapor barriers and thermal storage. Prerequisite: ENRGY 100, CONST 110 and 160 recommended.

ENRGY 130 - SOLAR ENERGY CONCEPTS (3 credits)

This course will acquaint the student with the basic technology of solar heating, the application of solar energy in the home and business, and provide background for wise decision making effecting his energy future. Physical concepts of light and heat will be presented as related to collection, storage and utilization of solar energy. Prerequisite: None

ENRGY 140 - RENEWABLE ENERGY SYSTEMS (3 credits)

A survey of appropriate technology using small scale systems which can be built and used by individuals and small groups. Basic information and data needed for construction of devices that tap renewable energy sources will be presented and practical applications in the North West will be discussed. Topics will include: energy from conservation, sun, wind, water, and biofuels: and integrated building systems. Prerequisite: None

ENRGY 150 - FUNDAMENTALS OF HEAT TRANSFER (5 credits)

Heat and heat flow: principles measurement, and applications in energy system design and operation. Topics include: heat and temperature, thermo-dynamic laws, thermo properties of materials, heat transfer, heat recovery and cogeneration, heat engines and power generation, refrigeration and heat pumps. Prerequisites: High school physics or Physics 140, and ENRGY 100.

ENRGY 160 - ENERGY ELECTRONICS (4 credits)

A survey course for non-electronics majors in the two-year technical program. Basic AC/DC and electronic theory will be discussed as well as a survey of practical uses of electronics as it relates to building electrical systems and energy conservation. Prerequisite: CONST 175, with ENRGY 100 recommended.

Page 2 - Course Descriptions

ENRGY 210 - ENERGY AUDITING/CALCULATIONS (5 credits)

Energy use in residential and light commercial buildings, their shell, mechanical, electrical and human systems will be studied. Students will learn intensive and extensive analysis of building heat losses and gains, economic analysis of conservation alternatives including life cycle costing through laboratory sessions consisting of energy audits of local buildings. The role of proper maintenance in reducing energy use will be covered. Prerequisite: High school algebra or MATH 60, ENRGY 150.

ENRGY 211 - COMMERCIAL BUILDINGS (5 credits)

This course will discuss the many different types of commercial buildings, construction techniques and materials in both new and existing structures. Topics covered will include: mechanical and electrical systems and their operation, thermal balancing, and maintenance. Field studies of industrial energy auditing in the community will be used as real examples. Prerequisite: CONST 170 and ENRGY 100.

ENRGY 220 - ENERGY CONTROL SYSTEMS (3 credits)

Energy Control Systems will provide an in-depth study of the function and use of devices that regulate energy use in buildings. Both manual and automatic control of simple switches through programmable microprocessors will be studied with emphasis on conserving energy. Core material including control logic plus several guest speakers from the controls industry provide an interesting and informative format. Prerequisite: ENRGY 110, 210, and 160 or equivalent experience with permission of coordinator.

ENRGY 230 - ADVANCED SOLAR ENERGY CONCEPTS (3 credits)

This course will include detailed analysis of solar heating and cooling systems in residential and industrial applications, and the integration of solar with other heating systems. Photo-electric conversion will also be studied. Other topics will include: equipment survey, installation techniques and control systems. Prerequisite: ENRGY 130.

ENRGY 285 - ENERGY BUILDING CODES (3 credits)

New building, plumbing, electrical and mechanical codes pertaining to energy will be studied in detail. National, state, county and city building requirements as they relate to conservation and new alternative energy sources will be investigated. Emphasis will be placed on local energy codes. Prerequisite: CONST 280.

ENRGY 299 - SPECIAL PROJECTS/INDEPENDENT STUDY (1-5 credits)

College credit for individual projects in energy, especially involving energy management in buildings or in engineered processes, solar, or other renewable energy systems. Example projects might include an installed solar water heating system, an energy conservation and management plan devised and carried out at one's home or place of business, building an energy conserving device (e.g., electric car). The range of projects is vast, but the project must effect real changes that result in energy savings. Prerequisite: Faculty sponsor and approval of division representative.

ENRGY 155 - ENERGY UPDATING SEMINARS (1-5 credits)

Updating energy seminars would contain information on current issues or problems facing energy consumption, conservation and/or renewable energies and to supplement existing energy courses. Possible topics might include: new types of energy control devices, energy "fairs", consumer awareness of energy conservation measures, workshops on installation techniques, etc.

ENRGY 292 - ENERGY COOPERATIVE WORK EXPERIENCE SEMINAR (1 credit)

For students enrolled in Energy Cooperative Education. A career-related course designed to assist students in developing their job objectives, exploration of career options, and the development of work attitudes.

ENRGY 293 - ENERGY COOPERATIVE EDUCATION (Maximum 3 quarters/15 credits)

Students are employed in a career-related work assignment in the community, coordinated by the college and the employer, to provide on-the-job training as a learning experience.

ENERGY MANAGEMENT

(SUPPLEMENTAL PROGRAM)

ATA DEGREE REQUIREMENTS

In order for a student to receive an ATA Degree — Energy Management, the student must take a minimum of 50 credits in energy courses, 35 credits in general requirements courses, 3 credits of PE/Health (college requirements) and 10 credits in the elective area. (Other courses can be substituted by the Energy Management Coordinator).

A typical student schedule would be as follows:

FIRST YEAR

credit hours

Fall

ENRGY	100	Introduction to Energy	5	
ENRGY	130	Solar Energy Concepts	3	
CONST	170	Introduction to Mechanical Systems	3	
ECON	201	Principles of Economics	5	16

Winter

ENRGY	140	Renewable Energy in Construction	3	
ENRGY	150	Fundamentals of Heat Transfer	5	
MATH	115	Computer Programming	4	
CONST	120	Introduction to Construction (C&R)	3	14

Spring

ENRGY	110	Materials and Design in Conservation	3	
ENRGY	210	Energy Auditing/Calculations	5	
CONST	141	Blueprint Reading - I	4	
CONST	170	Introduction to Mechanical Systems	3	
		Elective	3-5	16-19

SECOND YEARFall

ENRGY	160	Energy Electronics	4	
ENRGY	230	Advanced Solar Energy	3	
CONST	280	Building Codes - I	3	
ACCTG	201	Accounting	5	
		Elective		18-23

Winter

ENRGY	220	Energy Control Systems	3	
ENRGY	211	Commercial Buildings	5	
ENRGY	191 & 192	Cooperative Education	1-6	
ENRGY	299	Special Projects	5	14-19

Spring

ENRGY	285	Energy Building Codes	3	
ENGL	111	Technical Writing	5	
ENRGY	191 & 192	Cooperative Education	1-6	
ENRGY	299	Special Projects	5	14-19

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY

100

*Course abbrev.

*Course number

Check ONE: ☒ NEW COURSE PROPOSAL: complete ALL items below.
☐ SYLLABUS UPDATE: complete only items marked with asterisk (*).
☐ REVISION: specify change _____

*COURSE TITLE: INTRODUCTION TO ENERGY

STUDENT CLASS HOURS:	55						
	lect.	lect/ lab.	lab	shop	clin.	other	syst.
5	55	35		.333			
Credits	Instructor contact hrs.	Capacity (est.)	FTEF fraction	Fee	REGIS code		

PREREQUISITE: NONE

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer	☒ occupational preparatory	☐ community service
☐ academic basic	☐ occupational supplementary	
☐ academic general	☐ occupational "useful"	

SPECIAL CLIENTELE TO BE SERVED:

People interested in the energy field, energy management technician and construction technology students.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution ☐ ☐	AAS electives ☐ ☐	AAS electives ☒ ☐
(transfer only) yes no	(transfer only) yes no	(15 credit block) yes no

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ ☒
yes no

CATALOG DESCRIPTION:

This course will cover the history of energy use and the development of the energy crisis. Topics to be covered will include: Application of appropriate technology; energy concepts and terminology; alternative futures; useful forms of energy (renewable and non-renewable); solar space heating at the residential level; conservation and generation. In addition, field trips will be incorporated to orient the student to energy principles.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

Upon completion of the course:

1. The student will be able to understand the history and steps leading up to the energy crisis and current situation.
2. The student will be versed in energy concepts and terminology.
3. The student will have basic concepts in energy conservation and generation.
4. The student will have been oriented to the energy field which will enable them to enroll in further courses in the energy management technician program.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

Lecture, discussion and field trips, supplemented by guest speakers (See week #8).

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Quizzes, homework assignments, mid-term and final exams

***GRADING:**

Course Standards:

Midterm	20%
Final	30%
Report	25%
Attendance & Problems	25%
	<u>100%</u>

Grading Schedule:

90-100%	A
80-89%	B
70-79%	C
60-69%	D
59% or below	E

***DETAILED COURSE OUTLINE:**

Text: Doolittle, "Energy--a Crisis, a Dilemma, or Just Another Problem"

Outline of weekly topics, reading assignments, and written problems (assigned for following Tues.):

- 9/25 1. Intro to energy management program; energy perspectives.
Read Chapters 1 and 26.
Written: self-report on energy-related experience, education, viewpoints, course expectations and career goals.
- 10/2 2. What is energy? Fundamental laws and relationships; energy-use sequence--source to purpose
Read Chapter 2.
Problems, Chapter 2 plus instructor's problems.
- 10/9 3. Units of energy--interconversions; forms and experiences.
Read Chapter 3.
Problems, Chapter 3, plus instructor's problems.
Write an account of your typical day's energy use in terms of energy sources and energy conversion processes at work; if you can, discuss efficiencies of conversion.
- 10/16 4. Global flow, natural balance, ecological equilibrium. Photosynthesis & fossilization. Geothermal, nuclear, chemical sources and forms.
Survey Parts II and III of the book--Chapters 6-20 (some will be reviewed in more detail later).
Selected problems from these chapters, plus instructor's problems.
- 10/23 5. Mechanisms and devices for conversion.
Read Chapter 4 and Chapters 21-23.
Selected problems from these chapters, plus instructor's problems.
MIDTERM Thursday will cover first four weeks.
- 10/30 6. Historical overview. Prehistory to 1700; industrial revolution to 1960.
Submit written term report or outline plus talk on energy use at some time and place in history, or on detailed analysis of own daily usage -- or report on alternative topic approved by instructor. Suggested: any desired pictures, tables, photos, etc.
- 11/6 7. Present uses, global and regional. Other peoples -- resource distribution, politics. Pacific Northwest -- hydropower, use distribution.
Special instructor's problems.
- 11/13 8. Present uses--Snohomish County. Energy distribution--PUD, WNG, Standard Oil, etc. Industry--Boeing, aluminum, forestry, agriculture, etc. Transport--trucking, port, rail, public transit, etc. Residential and commercial.
This week will feature guest speakers. Main task will be careful questioning and involvement with these speakers.
- 11/20 9. Prelude to the future: 1960's and 1970's: Personal history and involvement.
Read Chapters 24, 25, 5.
Problems in these chapters, plus instructor's.
- 11/27 10. Future? Issues of environment, economics, peace, etc.: problems & solutions.
Possibilities for personal involvement.
Complete your course review, finish up all reports and problems
- FINAL

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1. _____	Course proposal form submitted to the office of the associate dean of instruction	_____
2. _____	Page one completed.	
3. _____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4. _____	Reviewed by director of learning center	_____ (DLR)
5. _____	Reviewed by Faculty-Administration Council.	
6. _____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7. _____	Course proposal form filed in temporary location.	
8. _____	Pages two and three completed (prior to the end of the quarter in which taught).	
9. _____	Page four completed.	
10. _____	Course proposal form filed in permanent location.	

STUDENT OBJECTIVES AND CHARACTERISTICS

ENERGY 100 - INTRODUCTION TO ENERGY

STUDENT OBJECTIVES AND CHARACTERISTICS

ENERGY 100 - INTRODUCTION TO ENERGY

1. Students learned about the course through the college schedule, other, brochure, newspaper (prioritized)

2. Purpose for enrolling (in order of largest percentage)

For personal enrichment or to explore educational opportunities - 31%

To prepare for a job in a new field - 28%

To complete two years of education which might qualify for an Associate of Technical Arts degree - 20%

To augment existing job skills - 14%

To transfer courses with the intent of transferring credits to a four year institution. - 7%

3. Student credit hour loads were as follows:

6 - 9 credits 33%

10-14 credits 29%

Less than 6 24%

15-18 credits 9%

More than 18 5%

The average credit load for this class was 8 credits /student.

4. 66% of the students were employed an average of 40 hours or more per week.
5. 90% of the students planned on continuing in the program.
6. The average age of students enrolled in this course was between 26 and 35 years.

(see attached for additional comments)

Intro. to Energy - Enrgy 100

IF EMPLOYED: JOB TITLE/POSITION, HOW LONG IN INDUSTRY

Assistant Building Manager
Marchandler, 11 years
Clerk, 1 year
Bricklayer apprentice, 2 years
Investigator/partner, 2 years
Painter, 10 years
Field glazer, 3 years
Boilermaker/shipyard mechanic, 4+ as much as 3 years related
Dental assistant, 2 years
Carpenter, 4 years
Manager of Bicycle Shop, 5 years
Interviewer for Census, 6 months
Carpenter, 4 years
Manager, 2½ years

WHAT DO YOU HOPE TO LEARN FROM THIS COURSE?

Better and effective energy management of our Natural Resources.
Total energy spectrum
A better understanding of our energy needs, how we got in this situation and some facts on our energy sources.
Basic aspects of energy
Energy technology
As much as possible of soft/alternate energy paths
A lot about energy
About energy, what it is, why it is and how it works
An understanding of energy management
Basic knowledge dealing with energy functions
I hopw to learn all about energy and what I can do to improve the status quo.
About energy and how to use it to the maximum capability.
To use these skills for personal use.

WHAT IS YOUR REASON FOR TAKING THIS COURSE?

Self improvement
To facilitate more knowledge of energy than I will learn in other classes
It sounds like a super career and one of this nation's top priorities for the future.
Because it was there, and an interest
Choices 2, 4, and 5 of question #3.
To learn more about the above. To apply what I learn to what I would like to do.
Hopefully to help myself in an energy orientated occupation.
To learn soft/alternate energy paths.
Expanded horizons.
Basic aspects of energy (to learn)
I am using this as a step for getting into the energy conservation/management field. Also, simply to learn about our most important problem.
Applicable towards future employment possibilities.
AA, knowledge.

TEACHING METHODOLOGY

ENERGY 100 - INTRODUCTION TO ENERGY

Assign. Read: Chapter 1 Intro. To Energy Situations

26 General Summary

Comment: Must question much of what book says. Even as these chapters supply a good lead-in set of facts and questions.

- p. 2 Life improved in and before mid-ages thru use of draft animals, greater meat consumption.
- p. 4 (1), (5), (8) typical of this book and most every other source is equation of "energy" with "resources marketed for their energy content"
But marketed energy of all kinds is $\leq 1/10$ of 1% of all "energy income" on earth which income is, in a sense, all "consumed" or "used". This income, by the way, is $\sim 99.8\%$ free solar, $.1\%$ geothermal, $.1\%$ marketed resources.
- p. 7 Suppl. A, first sentence. Wrong - by being sensible, we could conserve without "of necessity"
- p. 8 deprivations described = actual lifestyle of many in class either now or in past
- p. 10 "or unless we allow the energy companies."
Remark mistakenly assumes that those companies which pass for "energy" suppliers today are necessarily the same companies which will, or should be, our "energy" suppliers in future. Fallacy: that those who supply oil should be particularly expert in supplying solar or nuclear, or leading conservation efforts.

Book ignores role of conservation

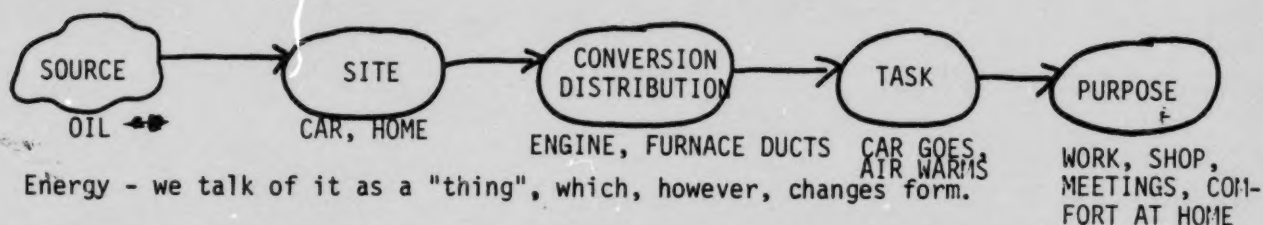
Introductions: Why are we (individually) in this class? Each person identify self occupation, background, goals from class, anything else, briefly, of interest.

Go over outline and procedures. Comment on choice of text ("least of evils").

Be sure everyone knows about EIT program has copy of description.

Explain assigned report

Our use of energy: use sequence:



Energy - we talk of it as a "thing", which, however, changes form.

We therefore find it useful to believe that different phenomena are really just instances of same thing: energy. That is, the total amount of energy stays same (is "conserved", not what we mean by "conserving" use of energy)

This is called the first law of energy (or thermodynamics)

But what are these forms? What is evidence that they are really just aspects of the same thing, energy? (Quickly: they convert to one another at "fixed exchange rates", much as we regard different national currencies as being just different forms of the same thing, monetary wealth.) What units are used to measure amounts of these forms, hence amounts of energy?

In-class:

Forms of energy - first law.

mechanical - work, kinetic, potential (electrical, etc)

heat - latent, sensible

chemical - combustion, heats of reaction, heating values

Measurement and units: definition

ft - lb, newton - n = joule, kJ, power: watt, kW, energy - kWh, btu, kcal.
btu used henceforth.

Heat Work: heat engine: Fig 2-6

Heat Heat moved (rejected) + work

Work Moving heat: Figs 2-8, 2-9

Work + Heat moved from cold = heat delivered to hot

heat pump or refrigerator

Carnot efficiency, second law.

How to do problems Ch. 2

Forms of energy:

1. "work"

what we need in order to move objects over distances against forces: work =
force X distance

2. "motion (kinetic) energy"

what we need in order to get an object of given mass (m) to be moving at
some speed (or velocity)(v)

$$KE = \frac{1}{2} \text{ mass } \times (\text{velocity})^2$$

by doing work on an object at starting rest, we give it k.e. We release this K.E.
by having the object collide to a stop.

3. "position" or "potential" energy (PE)

We toss a ball high up in the air - maybe to top of diff. we put in a lot of work

Week 2 con't.

in order to start off with a lot of KE - what happened to it?

Well, it's now in form of PE - ball is now in position to give us back all the KE we put into it, if we just nudge it back over the cliff and let it fall.

The above are all called "mechanical" energy - the first law of energy ("conservation") was stated just for mechanical.

Energy: work done (on tossed ball) = KE acquired by ball

Example: = later PE = yet later KE = work done (by ball, on smashing onto ground)

But this analysis isn't quite right. The ball's smash goes into producing heat.

Measurement of mech. energy:

work = Force X distance, so unit used is unit of force, unit of distance

= pound-force X foot, called ft-lb

the weight of a 1 lb. object: in other words, the force of gravity (std. conditions at earth's surface) exerted on a 1 lb. object

Metric: newton X meter = joule

where 1 newton = force on a 1 kg. object (1 kg. = mass of 1 liter of water, sufficient to accelerate it (increase its speed) by 1 meter/sec. each second. a cube of water 1/10 meter on a side, and about 1 quart or 2 pts. or volume of 2 lbs. water)

This definition of force-unit is based on Newton's great law: Force on an object = mass of object X acceleration produced by the force.

Heat energy creates phase (latent heat) change, or temp. change (sensible heat)

Heat needed (to produce temp. change) = (mass of material) X (heat storage capacity per unit mass) X (temp. change)

1 lb. of water takes a certain amount of heat to be raised 1°F, namely a btu (British Thermal Unit), our fundamental unit of energy.

Metric measure:

1 kg. (or liter) of water takes 1 k-calorie to be raised 1°C

Temperature scales:

	water		water
	freezes		boils
F	32	180 degrees	212
C	0	100 degrees	100

1 kg $\approx$ 2 lb

1 C $\approx$ 2 F

1 kcal $\approx$ 4 btu.

It so happens that 1 btu $\approx$ 1,000 joules = 1 kilojoule so btu is almost a good, practical energy measure in metric, too.

If we deliver energy at rate of 1 joule/second, we get 1 watt of power.

If we do this for an hour, we get $3600 \text{ sec} \times 1 \text{ kJ/sec.} = 3600 \text{ kJ}$
We also call this a kWh.

So $1 \text{ kWh} = 3600 \text{ kJ} \approx 3600 \text{ btu}$

Actually, since a btu is a little bigger than a kJ, $1 \text{ kWh} \approx 3613 \text{ btu}$.

Electric energy - energy of moving electrons, is thus measured in units of mech. energy - only right, since mech. energy represents energy of motion.

Second Law. Energy is conserved - but amount of usable energy is always decreased.

Related facts:

Heat moves from hot to cold. Temp. differences are being reduced.

Since heat can be converted to mech. energy only by using a temp. difference, this means that mech. energy is ever less available.

Why should conversion tend to be only in direction $\longrightarrow$?

Well, mech. energy represents very organized motion: a moving ball consists of zillions of molecules all moving, parallel, together. Heat, however, represents unorganized motion, the random every-which-way motion of individual moles. with respect to the center of the ball. It is nearly impossible to convert unorganized to organized, but reverse is possible--as when ball collides and shatters to smithereens.

Energy demands.

Go through book's statements, tables, problems on use of tables

Note that energy is used (almost equally) in four areas: buildings, industry, transport, electric generation and that electric generation is not an end use, but a conversion. Conservation opportunities include eliminating some of this conversion by using energy in non-electric forms.

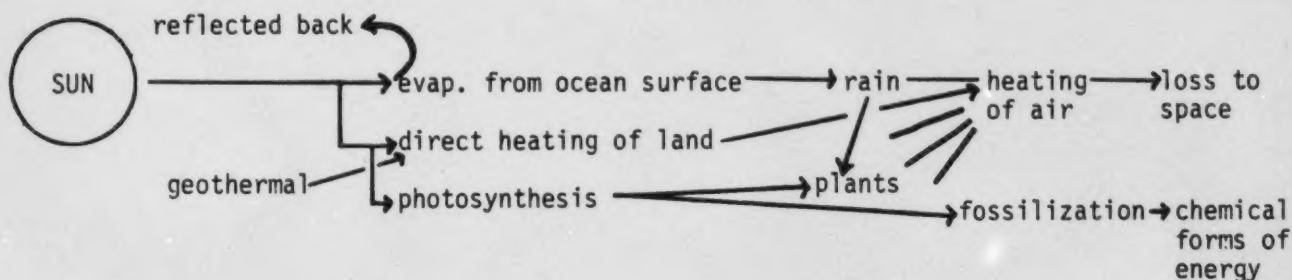
To what extent can various sources be employed flexibly for the various end uses?

Discuss assigned account of daily energy use.

Review concept of efficiency (of a given conversion step)

Review Week 2

Earth's energy income--see Thorndyke's book's chart for details



Effects of man. sunspot cycles, earth orbit on:

solar radiation received
solar radiation reflected
desertification. Ice ages, glaciers

Photosynthesis → life.

effects of food chains and conversion efficiencies

Survey chapters 6-20. Different energy sources. Emphasize that idea is to learn rudiments about these: resources, their extraction, transport, processes verting or reacting them to usable energy, resulting "heating values", environmental effects, economics.

Answer sample questions at end of each chapter - whatever seems interesting

E 100 Week 5

1. Assign reading: chapters 4, 21-23 for some overview:
2. Do sample problems. Ask class to do other problems of interest
3. Review weeks 1-4
4. Call attention to term report (written, or scheduled as talk). Review what is expected

E 100 Week 6

Historical overview.

Ask class to answer questions through discussion.

Prehistory to 1700

Energy "needs", typical "uses": agriculture, home, industry, transport,...

How met? Sources: (sun, fire-wood, wind (sails, mills, Etc.), water

How used?

Industrial Revolution

Same questions, explore changes

New uses--

New sources coal, oil, natural gas: nuclear

How "new" is coal? (China, old)

How "old" is animal? (Whale oil, primarily in 19th cent.)

Trace history of use of coal, oil, nat. gas, nuclear,.....

Global and regional uses - present

Class discussion, to answer:

World

Oil, gas, coal; uranium; wood;...

Who has how much _____?

Where ~~are~~ each used?

How important in economy?

International relations? Conflicts?

USA

Same questions. How different from world?

Pacific Northwest

Same questions. How different from USA?

Electricity from hydro.

How does the electric network operate here?

Review difficult problem areas of text. Especially Ch. 2

Snohomish County

Survey of uses.

Roundtable, guest speakers

1. Sno. PUD - Jack Danforth
2. Texaco or Chevron--
3. Transport - Gleason, EdCC

Note Short quiz next week on basics of these talks.

Note: employment opportunities?

Impending growth or opposite?

Proposals for more efficiency?

What problems do they see ahead?

Brief history of their organization and its role?

Impact on Washington State, Puget Sound, Snohomish County?

Future - prelude

Chapters 24, 25, 5:

Future challenges.

1. ~~Conservation~~ - oppo. demands - have class list reasons and benefits, methods and needs.
2. see text's options p 275-6, questions: How does extraction of sources conversions, uses of energy affect environment?
Be sure to note: CO₂ and combustion emissions, neodroactivity, strip and c. mining, oil spills--What do each of these do?
3. Economy, Which sources and uses can we afford?
Note: solar, etc. means substituting for on going fuel costs up-front capital expenditures. See Ch. 5 for issues involved. "Review" methods of working the problems there.
4. Personal: instructors' and student's recent history, reasons for involvement in energy. How do these translate into action programs?

Course review - Sample final.

SUPPLEMENTAL INSTRUCTIONAL MATERIALS

ENERGY 100 - INTRODUCTION TO ENERGY

Considerations in rating each source (both present facts and trends)

Heating value (btu/unit, given process)

Renewability

Cost (\$/unit) to user

External (environmental) cost

Net energy obtained

Efficiency (of needed conversion process)

Quantity

Dispersion

Accessibility in place

Transportation requirement

Quality (characteristic temperature, etc.)

Storability

Safety

Ease of conversions

Agreeability, convenience of use

Public acceptance

Demand

Need (substitutability)

Savings possible by switching to source or by switching process used

Importance

Uses

SOLUTIONS OF PROBLEMS

ENERGY: A CRISIS, A DILEMMA, OR JUST ANOTHER PROBLEM?

Chapter 2

2-1. Eq. 2-1a, $F' = m \frac{a}{g_c}$, $a = \frac{40 \times 32.174}{20} = 64.35 \text{ ft/sec.}$ ans.

2-2. Barometric pressure = $29.67 \times 0.491 = 14.57 \text{ nsia.}$
Gage pressure = $170.2 - 14.57 = 155.63 \text{ psig.}$ ans.

2-3. Eq. 3-2, $^{\circ}F = ^{\circ}C \times \frac{212-32}{100} + 32 = -40 \frac{180}{100} + 32 = 40^{\circ}F.$ ans.

2-4. Eq. 2-6, $Q = mc(T_2 - T_1)$, $T_2 - T_1 = \frac{2700}{150 \times 1} = 20.77$
 $T_2 = 80 + 20.77 = 100.77^{\circ}F.$ ans.

2-5. a) $W = p(V_2 - V_1)$ (Since the pressure is constant).
 $V_2 - V_1 = \frac{400}{110 \times 144} = 0.028 \text{ cu.ft.}$ ans.

b) It is not necessary to know the diameter.

2-6. Total increase in energy = increase in kinetic energy + increase in potential energy.

Final velocity = $\frac{50 \times 5280}{3600} = 73.33 \text{ ft. per sec.}$

Kinetic energy = $\frac{mV^2}{2g_c} = \frac{2 \times 2000 \times 73.33^2}{2 \times 32.174} = 334,300 \text{ ft. lb.}$

Potential energy change = $m(Z_2 - Z_1) = 2 \times 2000 \times 250 = 1,000,000 \text{ ft. lb.}$

Total increase in energy = $334,300 + 1,000,000 = 1,334,300 \text{ ft. lb.}$ ans.

2-7. Total work = $mZ = 6 \times 2000 \times 98 = 1,176,000 \text{ ft. lb.}$

Work per min = $\frac{1,176,000}{2} = 588,000 \text{ ft. lb.}$

Power = $\frac{588000}{33000} = 17.82 \text{ hp.}$ ans.

2-8. Energy supplied per hour = $750 \times 42 \times 140,200 = 4.416 \times 10^9$ Btu.

Output = $\frac{4.416 \times 10^9}{3413} \times 0.405 = 524,000$ kw.

ans.

2-9. Eq. 2-17, $\eta_t = \frac{T_h - T_l}{T_h} = \frac{400 - 80}{400 + 460} = 0.372$ or 37.2%.

ans.

This calculation shows that when the heat rejection temperature is reduced from 1200°F to 800°F, the efficiency increases from 32.6% to 37.2%, a significant increase.

2-10. Eq. 2-17, First engine, $\eta_t = \frac{540 - 40}{540 + 460} = 50\%$

Eq. 2-16, $\eta_t = \frac{W}{Q_s} \cdot Q_s = \frac{100}{0.5} = 200$ Btu.

Second engine, $\eta_t = \frac{140 - 40}{140 + 460} = 16.67\%$

$W = \eta_t \times Q_s = 0.1667 \times 200 = 33.33$ Btu.

ans.

2-11. From Eq. 2-17, $W = 50,000 \frac{120 - 10}{120 + 460} = 9483$ Btu.

Then for refrigeration, power = $\frac{9483}{3413} = 2.778$ kw.

ans.

A decrease in the low temperature from 50°F to 10°F increases the theoretical power required from 1.768 kw to 2.778 kw, a 57% increase.

2-12. The increase in internal energy of the fluid will equal the heat added only when there is no energy delivered during the process, particularly as work.

2-13. Kilowatts required = $\frac{50,000}{3413} = 14.65$ kw.

ans.

2-14. Electrical work delivered per lb. = $(h_1 - h_2)\eta =$

$(1450 - 910)(0.97) = 523.8$ Btu.

Work required per hour = $750,000 \times 3413 = 2.56 \times 10^9$ Btu.

Lb. per hr. = $\frac{2.56 \times 10^9}{523.8} = 4,887,000$ lb.

ans.

Chapter 3

3-1. Btu of coal produced per day = $7.4 \times 10^6 \times 5.8 \times 10^6 = 42.92 \times 10^{12}$ Btu.

Tons of coal produced per yr. = $\frac{42.92 \times 10^{12} \times 365}{13,000 \times 2000} =$

602,500,000 tons.

ans.

In the same manner, the coal used per year = 529,200,000 tons.

ans.

3-2. The thermal efficiency = $\frac{\text{Output}}{Q_s}$

Millions equivalent bbl per day

	Q_s	Output	Thermal Eff.
1950	1.9	0.5	26.3%
1960	3.4	1.1	32.3%
1970	7.1	2.5	35.2%
1980	13.2	5.1	38.6%
1990	22.5	7.5	34.6%

The increase in operating steam temperatures and pressures in fossil fuel plants accounts for the increase in thermal efficiencies. It is assumed that a significant percentage of the electric power produced in 1990 will be in nuclear power plants. These plants, operating at lower steam pressures and temperatures, have a lower thermal efficiency and hence reduce the overall thermal efficiency.

3-3. a) Energy input to hydroplants in 1990 = 0.8 million bbl. per day equivalent

Energy input to hydroplants in 1950 = 0.2 million bbl. per day equivalent

Ratio = $\frac{0.8}{0.2} = 4$ to 1

b) 1950, percentage for hydroplants = $\frac{0.2}{1.9} \times 100 = 10.53\%$

1990, percentage for hydroplants = $\frac{0.8}{22.5} \times 100 = 3.66\%$

3.4

Millions equivalent bbl per day
Percentage
for coal

	Total	Coal	Percentage for coal
1950	1.9	1.1	57.9
1960	3.4	2.0	58.8
1970	7.1	3.7	52.1
1980	13.2	5.2	39.4
1990	22.5	6.8	30.2

3.5

Equivalent million bbl per day Btu per year Population (millions) Btu per capita per year

	Equivalent million bbl per day	Btu per year	Population (millions)	Btu per capita per year
1950	15.4	32.6×10^{15}	152	214×10^6
1960	20.5	43.4×10^{15}	180	241×10^6
1970	31.6	66.9×10^{15}	204	328×10^6
1980	46.9	99.5×10^{15}	224	443×10^6
1990	66.8	141.4×10^{15}	246	575×10^6

3.6.

Millions equivalent bbl per day
Oil Percentage for oil

	Total	Oil	Percentage for oil
1950	15.4	6.2	40.3
1960	20.5	9.5	46.3
1970	31.6	13.9	44.0
1980	46.9	21.5	46.3
1990	66.8	29.3	43.9

3.7.

Millions equivalent bbl per day
Percentage for Natural gas

	Total	Natural gas	Percentage for Natural gas
1950	15.4	2.9	18.8
1960	20.5	5.9	28.8
1970	31.6	10.7	33.9
1980	46.9	11.9	25.4
1990	66.8	12.0	18.0

Chapter 4

$$4-1. \text{ Work per lb.} = \frac{V^2}{2g_c J} \times \eta = \frac{1800^2}{2 \times 32.174 \times 778} \times 0.84 = 54.43 \text{ Btu.}$$

$$\text{Work per hr.} = 92,000 \times 2544 = 2.34 \times 10^8 \text{ Btu.}$$

$$\text{Lb. per hr.} = \frac{2.34 \times 10^8}{54.43} = 4,300,000 \text{ lb. per hr.}$$

ans.

4-2. The volume rate of flow = Area x velocity

$$\text{Area} = \frac{38,760}{110} = 352.4 \text{ sq.ft.} = L^2$$

$$L = 18.77 \text{ ft.}$$

$$18.77 \text{ ft.} \times 18.77 \text{ ft.}$$

ans.

4-3. Amount of coal for 2.00 psia exhausts =

$$300 \frac{635.6}{571.8} = 333.5 \text{ tons per hr.}$$

ans.

4-4. At 0.5 psia, steam temperature = 79.6F.

$$\text{Circulating water temperature at exit} = 79.6 - 5.0 = 74.6F.$$

There are very little uses for large quantities of water at this temperature.

At 2.0 psia, steam temperature = 126.0F.

$$\text{Circulating water temperature at exit} = 126.0 - 5 = 121F.$$

When there is a demand for very large amount of building heating in the immediate vicinity of the power plant, water at a temperature of 121F should be useful for this purpose. This water may be useful for some agricultural purposes if such a demand was present in the vicinity of the power plant.

30

$$4-5. \text{ Total tube length} = \frac{80,000 \times 40}{5280} = 606 \text{ miles}$$

ans.

$$4-6. \text{ Volume of water} = \frac{37.7 \times 2000}{62.4} = 1208 \text{ cfs. (cu.ft. per sec.)}$$

ans.

$$4-7. \text{ Work per hr.} = 985,000 \times 3413 = 3.36 \times 10^9 \text{ Btu.}$$

$$\text{Lb. per hr.} = \frac{3.36 \times 10^9}{575} = 5,847,000 \text{ lb. per hr.}$$

ans.

FILMS AND REFERENCE RESOURCES

ENERGY 100 - INTRODUCTION TO ENERGY

FILM AND REFERENCE RESOURCES

ENERGY 100 - INTRODUCTION TO ENERGY COURSE

FILMS

"Solar Generation"

"Energy from the Sun"

REFERENCE SOURCES

Energy Conservation Standards, Dubin and Long, McGraw-Hill, 1978

Heating, Ventilating and Air Conditioning, McQuiston and Park, Wiley, 1977

Solar Law, Kraemer, McGraw-Hill, 1978

Solar Energy Thermal Processes, Duffie and Beckman, Wiley, 1974

Energy for Survival, Clark, Doubleday Anchor, 1974

The Energy Controversy, Lovins and Critics, Ed. H. Nash, Friends of the Earth, 1979

Introduction to Energy Technology, Shepard et al, Ann Arbor Science, 1978

Energy for Man, Thirring, Harper & Row, 1958

Soft Energy Paths, Lovins, Friends of the Earth, 1977

Energy and Environment, Thorndike, Addison Wesley, 1976

TESTING EVALUATION

ENERGY 100 - INTRODUCTION TO ENERGY

ENERGY 100 QUIZ November 27, 1979

1. Rate the following transport modes in order of decreasing energy efficiency: water, rail, pipeline, truck, auto, air.
2. Discuss prospects for employment in the energy field, especially with comparison and contrast between local utilities and oil companies.
3. How much oil is used daily in Washington State, and how & from where does it come?
4. Discuss opportunities for saving or extracting energy through changes in handling of garbage.

1. Compare present use and versatility of the following sources: wood, plants, animals, coal, natgas, oil, nuclear, direct solar. Be specific. Refer to uses in building heating, industrial process heat (over 100 C), transportation, etc.
2. "Hard" and "soft" energy paths differ considerably in the future of electricity uses and sources. Discuss. Use data of text or Lovins when appropriate.
3. Relate recycling to energy use. Can energy sources be recycled? Can energy itself be recycled? Should energy-wasting equipment be junked? What would be the most important impacts of passage of Prop. 61 ("bottle bill").
4. Water falls 100 feet and its energy of falling is converted totally (via turbines) to electricity. If 1000 lb per second of water fall (about 960 cubic feet per minute), at what rate (in watts or kilowatts) is electricity being generated? (Use equations 2-8, 2-13, or approximate: 1 btu = 800 ft-lb, 3 kWh = 10,000 btu.)
5. Water with temperature of 70F is cooled to 60F by a process which converts the lost heat almost totally into mechanical energy, and then in turn into electricity. If again 1000 lb per second of water are involved, at what rate is electricity being generated? Compare answer with 4.
6. A heat pump is supplying heat to a building (at the rate of 30,000 btu/hr) to maintain a temperature of 65 F, using a source at 40 F. What percentage of the supplied heat is in fact due to the mechanical energy input to the pump, and how many btu is this energy input, assuming that the heat pump uses the theoretical minimum? (Note equation 2-17.)

For reference: FINAL and COURSE EVALUATION.

FINAL (counting best seven out of the eight questions):

1. How do energy costs affect location of industry? Discuss one agricultural example and one non-agricultural example.
2. How has changed energy situation affected US foreign policy. Give example.
3. How has changed energy situation affected transport of goods or people? Give example.
4. What relationships exist between changes in energy consumption and growth of the "fast food" industry?
5. How--and from how far away--are non-renewable and renewable energy sources used to produce a slice of breakfast toast?
6. Which of the following is/are not necessarily attributes of "soft" energy paths?
1-scaled to use. 2-convenient to user. 3-versatile. 4-lower first costs.
5-diverse. 6-based on renewable flows.
7. How many foot-pounds of energy are released when 1000 pounds of water fall 250 feet?
1- $\frac{1000 \times 250}{32}$. 2- 1000×250 . 3- $\frac{1000 \times 250}{3413}$. 4- $32 \times 1000 \times 250$. 5-none of above.
8. How many kilowatts are used by an electric resistance furnace which puts out 34,000 btu per hour?

EVALUATION. Under each topic, suggest changes, and point out present strengths and weaknesses.

1. Expectations compared with actual course.
2. Suitability of content (for introductory course).
3. Instructors.
4. Text and readings.
5. In-class procedures.
6. Homework.
7. How well above factors (2-6) fit together.
8. Value as learning experience.
9. Etc.

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY

110

*Course abbrev.

*Course number

Check ONE: (X) NEW COURSE PROPOSAL: complete ALL items below.
 () SYLLABUS UPDATE: complete only items marked with asterisk (*).
 () REVISION: specify change _____

*COURSE TITLE: MATERIALS AND DESIGN IN CONSERVATION

STUDENT CLASS HOURS: 33 lect. lect/ lab shop clin. other syst.
3 3 35 .20 -0-
 Credits Instructor Capacity (est.) FTEF fraction Fee HEGIS code
 contact hrs.

PREREQUISITE: ENRGY 100, CONST 110 and 160 recommended

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

() academic transfer () occupational preparatory () community service
 () academic basic (X) occupational supplementary
 () academic general () occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

LISTING: one (and ONLY one) MUST be checked.

AAS distribution () () AAS electives () () AAS electives (X) ()
 (transfer only) yes no (transfer only) yes no (15 credit yes no
 block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? () (X)
 yes no

CATALOG DESCRIPTION:

How to design and build an effective energy envelope including; design strategies and innovations for new construction, devices and alternatives for energy use in existing buildings, materials used in conservation and how to use them properly, such as, insulation types, windows, control devices, vapor barriers and thermal storage.

***COURSE OBJECTIVES (standards against which student performance will be evaluated):**

Students will become aware of principal energy uses in and on account of buildings, and of major opportunities for cost-effective energy conservation through appropriate use of appropriate design and materials.

Students will become aware of importance and opportunities in overall building design of: sun, air, ground, vegetation and associated natural factors of the site; usage and human factors; energizing systems -- notably HVAC (heating, ventilation, air conditioning) and lighting; and built-in structure -- notably building envelope, and thermal mass.

Students will, in particular, become aware of means for controlling moisture, infiltration and heat-loss problems. Students will become aware of appropriate techniques, including materials used, places used, and purposes for use. Students will become familiar with basic means for providing energy-conserving natural and artificial lighting, and for working with conventional and improved heating and comfort systems.

***METHODS OF INSTRUCTION: (includes also special requirements for materials, space, support)**

Methods of instruction will include: lectures, discussion, homework, in-class demonstrations and a term project involving design of an energy-efficient structure. Guest speakers will also be utilized to supplement instructors.

***EXAMINATIONS (methods of evaluating student attainment of objectives):**

Examinations for evaluating student attainment of objectives will comprise of midterm and a final, with occasional brief quizzes.

***GRADING:**

Grading will be based on student participation, performance on examinations, and achievement in the term project.

Grading Schedule:

90-100%	A
80-89%	B
70-79%	C
60-69%	D
59% or below	E

*DETAILED COURSE OUTLINE:

1. Introduction. Basics of heat and comfort.

What is energy? Principal energy uses by and in buildings; heat (HVAC), light, appliances and services, materials, transport to and from.

Purposes of energy conservation in buildings: satisfaction and resource conservation, greater comfort at reduced cost. Reduced O&M costs for owners, users.

Sessions

1 and 2

Heat -- basics, temperature, heat capacity and energy content, thermal storage. Heat flow -- basics, radiation, conduction, convection, and their effect on comfort; clothing and insulation; human activities.

Phases -- basics. Vapor, moisture, condensation; vapor barriers; humidity and comfort

2. Overall design and plan choices.

Nature's givens: location; sun; air -- temperature and wind and precipitation; ground: temperature and moisture; vegetation and trees. Human givens: uses & users.

Chapters

1-8

Building elements: energizing systems, passive (non-energizing) systems, control mechanisms.

Sessions

3 and 4

Course will emphasize passive systems, as applied to tasks of HVAC and lighting in small (residential) buildings.

Survey of siting and overall design to conserve energy in other uses (see above list).

Sessions

5-8,

(Guest

speakers)

Survey of overall design approaches to conserve HVAC and lighting, in particular to minimize exposure, gain sun, moderate temperature and store energy. For example: Arkansas design (insulation, few windows), undergrounding, envelope, solar green-house attachment.

3. Moisture control.

Sessions

9 and 10

Why? To retain latent heat, stop water's heat conduction, stop damage -- freeze, rot and mildew.

How? Sheets, paints, flashing, drainage, exhausts, etc.

Where? Especially in kitchen, bath, greenhouse, below grade, etc.

4. Infiltration control, desired ventilation.

Sessions

11-12

Chapter 10

Why? Prevent unwanted loss of atmospheric heat, uncomfortable drafts.

How and Where? Caulk at windows, cracks; weatherstrip at doors, etc.
MIDTERM

Chs. 10/15 5. Control heat loss in opaque envelope.

Sessions

13 & 14

How and where? Various forms of insulations, for use in attic, wall, under floor, exterior, perimeter, below grade, around tanks and pipes, between interior zones.

Sessions

15 & 16

6. Natural and artificial lighting.

Glazed openings. Control of heat loss or gain via thermal shutters, etc. Lighting equipment.

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

- Sessions 7. Heating (and cooling).
17 & 18 Conventional central furnace systems and zoned electric resistance systems.
Ch. 11 Various alternatives: heat pumps, radiant systems. Fireplaces and wood stoves.
- Sessions 8. Service water and pool water heating.
19 & 20 conventional, solar, wood. Thermal storage -- passive integral: masonry elements,
Chs. 9, 12 water walls, salt containers. Thermal storage -- separate: water tanks, rock bins,
salt rooms:
- Session 9. Miscellany. Switches and controls. Energy-saving appliances.
21
10. Review. TERM PROJECTS discussed.
- Session 11. FINAL
22

PROCESS:

- | <u>Date</u> | <u>Procedure</u> | <u>By (signature):</u> |
|-------------|---|------------------------|
| *1. _____ | Course proposal form submitted to the office of the associate dean of instruction | _____ |
| 2. _____ | Page one completed. | |
| 3. _____ | Division recommends approval ()
Division recommends disapproval () | _____
(DR) |
| 4. _____ | Reviewed by director of learning center | _____
(DLR) |
| 5. _____ | Reviewed by Faculty-Administration Council. | |
| 6. _____ | Dean of instruction approves ()
Dean of instruction disapproves () | _____
(DI) |
| 7. _____ | Course proposal form filed in temporary location. | |
| 8. _____ | Pages two and three completed (prior to the end of the quarter in which taught). | |
| 9. _____ | Page four completed. | |
| 10. _____ | Course proposal form filed in permanent location. | |

TEACHING METHODOLOGY

ENERGY 110 - MATERIALS AND DESIGN IN CONSERVATION

Introduce instructor, course outline. Concept of term project.

Energy--

Forms of energy - mech $\leftarrow$ work
 $\leftarrow$ kin. energy
 $\leftarrow$ potential energy
 (energy of actual or possible motion)

 $\leftarrow$ electrical

(random, unseen motion) heat $\leftarrow$ latent (phase change)
 $\leftarrow$ sensible (temp. change)

Heat measured in btu - define

Mech. measured in ft-lb - define

Mech., elec., measured in Kwh - define

Ask students in each case for example for concept

Energy uses in buildings - ask for list, refer to outline, too.

Why conserve energy ? Ask for reasons, use outline, too.

Review and strengthen basics of heat.

Temp.

heat capacity - remind of btu

Energy content - thermal storage

flow of heat - hot to cold

mechanisms: in space - radiation

 inside a stationary material - conduction

 inside or between moving materials - convection

Note how we can measure flows:
(energy/time/area)

Flow of heat = number based on materials x area x temp. difference

$$Q = UA\Delta T$$

$$R = 1/U \times \text{resistance}$$

Effect on comfort of radiation
 conduction
 convection

gain: sun, fire/loss: through window, cold wall
 "wind chill"

Loss or gain due to air temp, inside/outside T, solar gams, metabolic gain,
appliance and light gains, clothing, insulation

Ask for examples and experiences

Phases: solid, liquid, vapor-gas

Ability of warm air to hold a lot more water.

Humidity, relative and absolute. Comfort conditions.

Condensation--Where? When? How relievable?
consequences

Permeation: vapor flow = permeance x area x (vapor pressure)

E 110 Week 2

Design and plan choices: (mainly residences)

What would you want to know about the site in order to determine where and how to place the house on it?

Develop topics as answers

Location, solar exposure, air temps., winds, rain, ground temp and moisture, vegetation.

What would you want to know about purposes of building? Who will use? How? For how long?, What? When?...

See outline topics: how can our knowledge of above factors be used to conserve energy in HVAX and lighting?

Ask class for examples of conservation tactics.

Ask what each one accomplishes, how it works.

Example: align house E-W: to maximize solar exposure - winter sun is in south.

E 110 Week 3

Is too much possible? Why? Where? (freeze damage, rot, mildew, etc.)

Is too little possible? Why? Where? (comfort, less heat storage)

When do we want moisture to move? When not?

Where do we want moisture to move? Where not?

How can we make moisture move? (Natural convection, fans, etc)

How can we prevent moisture from moving or moving in? vapor barriers, paints...

E 110 Week 4

Infiltration, review for mid-term

Why, Where control infiltration? Ask class.

How and where: caulk at windows, etc.
controlled air change and ventilation etc.

See outline.

Review first weeks. 1-4. Sample mid-term

Mid-term.

E 110 Week 5

Heat loss - opaque envelope

How to control and where?

What kinds of insulation are available?

What do we want to know about any given kind of insulation?
(R-value, how to apply, where OK, where no good...)

Have class develop list, then answer the questions.

At any given place (have class list as many different places as possible), what would you use and why?

E 110 Week 6

Lighting and glazed openings.

Have class answer and discuss:

What kind of non-opaque openings are there?

What are their functions?

How do these functions affect energy use, pro or con?

How does the construction of these openings affect energy?

How can we improve on these effects? (thermal shutters, etc.)

When we do need artificial lighting, what options are open? Where?

What kinds of glazings are available? Pros and cons.

Jo Yount - guest talk on window thermal coverings.

E 110 Week 7

Survey of heating systems.

There are many - how can we distinguish them and attempt to evaluate:

Source of energy? Gas, oil, coal, wood, electricity, solar,...

How used to make heat? combustion, resistance, heat pump

In what form is heat delivered? $\swarrow$ warm air (convection)
radiant surface

How is heat generated? $\swarrow$ Central "furnace"
room by room

Other question suggested by class...?

Discuss advantages/disadvantages of each answer to each question.

Look at HVAC system.

E 110 Week 8

Survey of systems for heating water: domestic as for week 7
pools

Discuss progress on individual projects - be sure students are making progress.

Thermal mass. Thermal Storage.

Why? (stabilize temp., avoid some needs to heat, cool.)

E 110 Week 9

Switches and controls.
Purpose?

Typical simple-minded control logic - thermostat

Critique how this can be changed for energy savings.

More sophisticated logic - solar domestic water heater.

Appliances

Wattage = amperage x voltage

Power = current x voltage
voltage = ?

Which appliances use most energy? How can we save on these?

E 110 Week 10

Review.

Sample final.

Note good points of any projects turned in.

(Reserve time for oral presentations)

Suggest and review what to include on projects.

SUPPLEMENTAL INSTRUCTIONAL MATERIALS

ENERGY 110 - MATERIALS AND DESIGN IN CONSERVATION

COOPERATIVE DESIGN

500 Aurora North, Suite 201 · Seattle, Wa. 98109 · (206) 682-8663

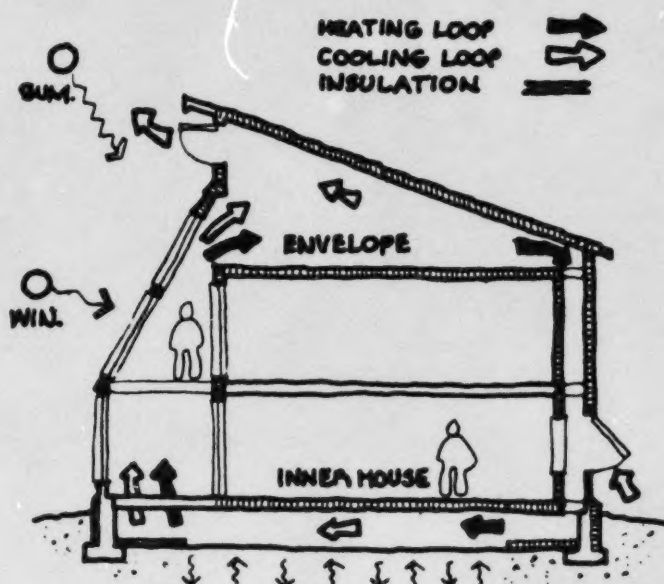
Cooperative Design was started in 1977 by John Raabe. Its purpose is to provide help in planning energy-efficient, low-technology homes and to develop simple building techniques that allow owners to do their own construction. John's background includes studies at the University of Washington in Architecture, two years as a Peace Corps architect in Iran, two years working with Ken Kern, author of The Owner-Built Home, developing low-technology construction techniques, and various terms with architectural offices in the Northwest and Hawaii.

CURRENT WORK

Over the last two years, Cooperative Design has been developing techniques that maximize the use of natural energies to satisfy the heating and cooling needs of buildings.

One technique which we feel holds a great deal of promise in this regard is the passive solar envelope principle. We have developed a Northwest adaptation of this design and have three houses currently under construction and several more in the planning stages.

An envelope house uses a solar-conditioned envelope of air around an insulated inner house to provide an intermediate zone to buffer the building from the outside environment. A large majority of the heating and cooling needs can thus be met by the utilization of solar energy, earth temperature and the thermodynamics of air. See sketch.



CLASSES

John is currently teaching two classes through the U. of W. Experimental College. Designing and Building For Yourself is an introduction to the design and home building process, dealing with codes, alternative building technologies and construction techniques. Passive Solar Workshop is an introduction to the use of natural energies for home heating and cooling. The envelope house and other systems are fully explained. For information on these classes contact the Experimental College at 543-4375.

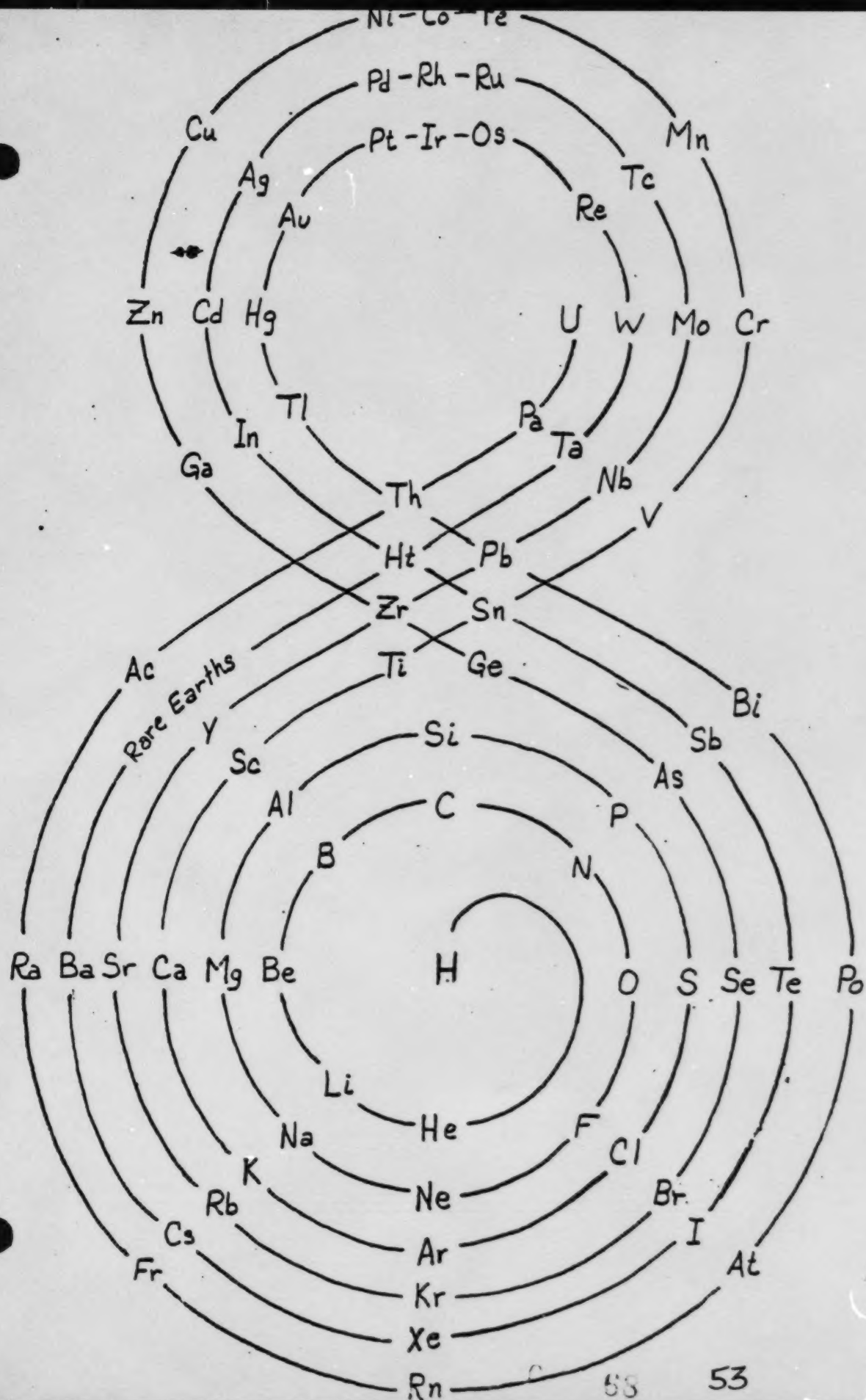
The New Shelter West Project is an intensive eight-week solar home design course in which students design and develop drawings for their own homes. Contact Cooperative Design for information concerning this course.

SERVICES

Design Services: Cooperative Design provides architectural design services that include advice and consultations, preliminary planning, construction and permit drawings, and construction supervision. We tailor these services to fit the client's needs and degree of participation. Full design services run from 6 to 12% of construction costs. The rate for design and consultation time is \$25/hr.

Housing Analysis: This is a structural and design analysis of an existing house with suggestions for repair priorities and possibilities for remodel. Cost: \$60 in city, \$15 additional for written report.

Solar Site Analysis: This is a site inspection with a charting of the solar energy available at that site and suggestions for its utilization or enhancement. Cost with chart and written report: \$75 plus travel time outside city.



CRITERIA FOR SOLAR HOME

I HOUSE ORIENTATION

- A. THE HOUSE SHALL BE LOCATED SO THAT IT HAS ACCESS TO SUNLIGHT AT LEAST 80% OF THE PERIOD FROM 9:00 A.M. TO 5:00 P.M. IN DECEMBER (JANUARY)

(USE SUN CHART FOR YOUR LATITUDE)

- B. PLACE THE LONG AXIS OF THE HOUSE IN AN EAST-WEST DIRECTION TO EXPOSE MORE WALL SURFACE TO THE SOUTH.
- C. THE EXPOSED AREA OF THE NORTH WALL SHOULD BE MINIMIZED TO REDUCE HEAT LOSS.
1. LOWERED ROOF LINES
 2. EARTH BERMS
 3. DENSE VEGETATION
 4. NORTH GARAGE/STORAGE LOCATION

II LANDSCAPING

LANDSCAPING SHALL NOT SIGNIFICANTLY SHADE THE SOUTH SIDE OF THE HOUSE DURING THE NOVEMBER THROUGH FEBRUARY PERIOD (MARCH)

- A. SHADE FOR THE WEST SIDE OF THE HOUSE DURING HOT SUMMER MONTHS
- B. SHELTER FOR THE NORTH SIDE OF THE HOUSE

III LOCATION OF INDOOR SPACES

- A. AT LEAST 20% OF THE AREA LOCATED WITHIN A DISTANCE OF $2\frac{1}{2}$ TIMES THE HEIGHT OF THE SOUTH WALL SHALL BE UTILIZED FOR DAYTIME LIVING SPACE (LIVING ROOM, DINING ROOM, FAMILY ROOM) TO TAKE ADVANTAGE OF THE NATURAL TENDENCY OF THE SOUTH SIDE TO BE WARMER DURING WINTER.
- B. MAIN ENTRANCE SHOULD INCLUDE AIR LOCK OR SHELTER FROM PREVAILING WINTER WIND TO REDUCE HEAT LOSS
1. VESTIBULE
 2. MUD ROOM
 3. WINDBREAK
 4. CONSIDER LOCATION OF MAIN ENTRANCE AWAY FROM PREVAILING WIND AT SITE

IV HOT WATER HEATING

THE CONVENTIONAL HOT WATER HEATER SHALL BE LOCATED WITHIN THE BUILDING INSULATION ENVELOPE TO RECLAIM HEAT LOSS FROM TANK.

- A. SPACE ADJACENT TO THE CONVENTIONAL WATER HEATER SHOULD BE AVAILABLE FOR A SECOND TANK OF EQUAL SIZE (SOLAR ASSISTED HEATING)

IV HOT WATER HEATING.

B. AT LEAST 70 FT² OF UNSHADED ROOF SURFACE OR OTHER AREA AT LEAST 3 FT WIDE SHOULD BE AVAILABLE FOR SOLAR COLLECTORS

1. SLOPE TO SOUTH 35° (8/12 PITCH) TO 55° (13/12)
2. INSTALL WATER LINES FOR FUTURE ADDITION OF SOLAR COLLECTORS/TANK IF FUTURE ADDITION WOULD BE DIFFICULT
3. CONSIDER GEOMETRY OF STORAGE TANK AND COLLECTORS FOR THERMOSIPHON SYSTEM (COLLECTORS LOWER THAN TANK ELEVATION)

V WINDOWS

A. ALL GLASS SHALL BE DOUBLE GLAZED. WINDOW FRAMES SHALL BE CAULKED IN PLACE AND ALL OPENING SASHES SHALL BE WEATHERSTRIPPED ON ALL EDGES

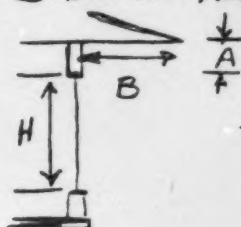
1. METAL SASHES SHOULD BE USED ONLY WHEN THEY CONTAIN A THERMAL BREAK
2. THERMAL SHADES OR SHUTTERS SHOULD BE CONSIDERED FOR LARGE WINDOWS AND SKYUTES

B. IF THE COMBINED AREA OF NORTH-EAST-AND WEST-FACING GLAZING, (INCLUDING CLERESTORIES AND SKYUTES) EXCEEDS 2% OF TOTAL FLOOR AREA, THEN THERMAL SHADES OR SHUTTERS WITH A MINIMUM "R" VALUE OF 5 SHALL BE PROVIDED TO COVER A GLAZED AREA AT LEAST EQUAL TO THE AREA IN EXCESS OF 2%.

V WINDOWS

C. THE AREA OF SOUTH-FACING GLAZING SHALL BE AT LEAST 6% OF THE TOTAL FLOOR AREA, AND WITHIN 20 DEGREES OF TRUE SOUTH.

1. SOUTH GLAZING SHALL BE SHADED BY CHERANG, LANDSCAPING, OR OTHER MEANS THAT PROVIDE FULL SHADE IN JULY AND FULL EXPOSURE IN JANUARY ACCORDING TO FOLLOWING FORMULA:



$$A = 0.195 H$$

$$B = 0.507 H$$

D. WINDOWS ON THE WEST SIDE SHALL BE REFLECTORIZED, SCREENED, OR OTHERWISE SHADED TO REDUCE LATE AFTERNOON SOLAR GAIN BY AT LEAST 40%.

VI THERMAL MASS

IF THE AREA OF SOUTH-FACING GLAZING EXCEEDS 6% OF TOTAL FLOOR AREA:

1. PROVIDE A MINIMUM OF 1 ft^3 MASONRY PER ft^2 OF SOUTH GLAZING IN EXCESS OF 6%.
2. PROVIDE 4 GALLONS OF WATER STORAGE PER ft^2 OF SOUTH GLAZING IN EXCESS OF 6%.
3. THERMAL MASS STORAGE SHALL BE WITHIN THE LIVING SPACE WITH A SUBSTANTIAL SURFACE AREA EXPOSED TO DIRECT SUNLIGHT PER PASSIVE SOLAR GAIN

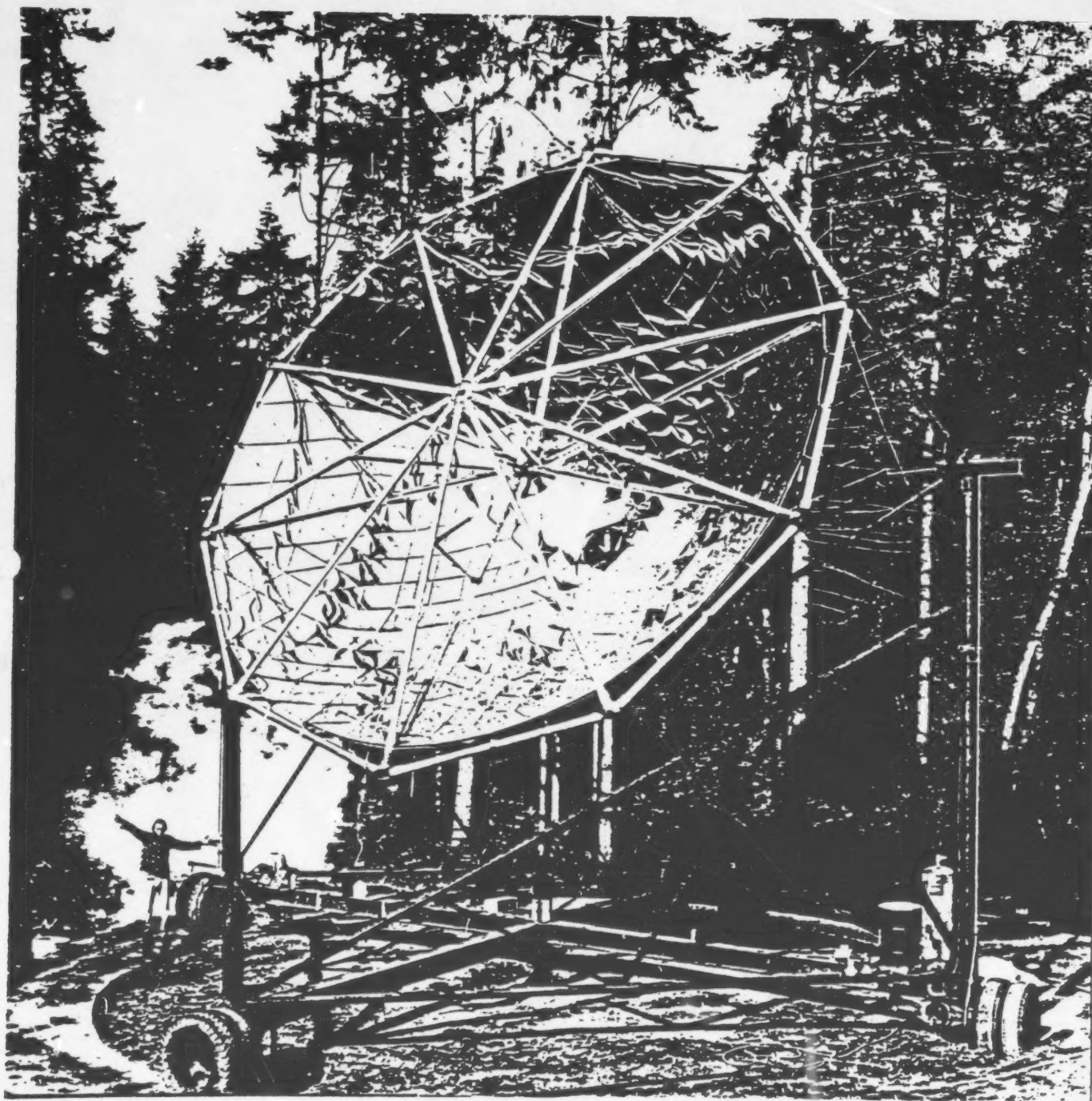
VII SPACE HEATING AND COOLING.

- A. THE HEATING SYSTEM SHALL BE A CENTRAL FORCED AIR TYPE, WITH HEAT PUMPS THROUGH THE LIVING SPACE.
- B. THE THERMOSTAT SHALL BE LOCATED IN THE DAYTIME LIVING SPACE AND PROVIDE BOTH AUTOMATIC NIGHT SETBACK AND COOLING MODE CAPABILITY.
(COOLING MODE TO OPERATE CIRCULATION FAN TO DISTRIBUTE SOLAR HEAT THROUGHOUT THE HOUSE)
- C. ALL FIREPLACES SHALL BE PROVIDED WITH A SUPPLY OF COMBUSTION AIR FROM OUTSIDE THE LIVING SPACE, AND MEANS FOR LIMITING THE LOSS OF CONDITIONED AIR UP THE CHIMNEY.
THE CHIMNEY BELOW THE ROOFLINE SHALL BE CONTAINED WITHIN THE INSULATION ENVELOPE.
- D. CROSS VENTILATION WHICH PROVIDES NATURAL COOLING SHOULD BE PROVIDED WITHIN THE HEATED SPACE.
- E. PROVISIONS FOR AIR-TIGHT WOOD STEVES SHOULD BE CONSIDERED DURING MASONRY CONSTRUCTION.

VIII INSULATION

ALL INSULATION SHOULD EXCEED COUNTY STANDARDS

- A. ROOF R-30
- B WALLS R-20
- C FLOORS R-20





Solar Steam, Inc.

P. O. Box 32
FOX ISLAND, WASHINGTON 98333

JOHN JESSUP
P.O. Box 403
STANFIELD, OR 97875
SOLAR HARVEST, INC
503/449-3592

BROCHURE

A contracted study of the market potential for small power systems in small electric utilities was conducted by Burns and McDonnell for the U.S. Department of Energy. They concluded that large paraboloid dish solar generators can be economically competitive and are more competitive when compared to oil and coal-fired utilities.

The Department of Energy primarily evaluates solar-thermal electrical generation for the value of the electrical generation alone. At least two-thirds of the total energy potential is wasted as heat to the environment. The Danes, however, use concentrating solar collectors only during the summer and only for heat. By capitalizing on the economy of seasonal heat storage tanks and district hot water distribution, they are able to supply 100% of community energy needs, supplying both base and peak heating and hot water needs. Under such a scheme, 50 homes would be 100% solar self-sufficient with 10 to 12 30-foot paraboloids connected to 5000 cubic meter seasonal storage tanks. If electricity is also produced, the power would go directly into the regional electrical transmission system saving oil, coal or water and giving the 50 homes an electrical credit for when the sun is not shining. The grid, not batteries, becomes a form of seasonal electrical storage.

Pictured here is the conclusion of phase one of our research. The purpose of this prototype was to test the economic feasibility of this technology and to test the geometric accuracy of geodesics for solar concentration. Geodesic geometry is normally used for the triangular construction of spherical or dome buildings, and is well known for expansive rigid strength and light weight construction. We were able to secure patent protection for the geodesic paraboloid. The prototype proves solar-steam-electric viability. The system uses approximately \$10,000 in new materials and can generate thermal energy rated at 40 kW peak output, 70,000kWh per year in average climate, and 2,100,000 kWh per 30 years. At a consumer cost of \$15,000 per unit (small units will also be developed) the energy will cost less than one cent per kilowatt hour.

A number of steps must now be taken to introduce this technology into the marketplace. These steps include design improvements, industrial engineering, production blueprints, production prototype testing, and mass production.

Financial investments are encouraged, as that is our sole source of research funds to date. Our effort has not been supported by large corporations or government agencies.

ENERGY AND POWER CONVERSIONS*

Reference 2

TO CHANGE:

FROM:

TO:

MULTIPLY BY:

Kilowatt Hours (KWH)	BTU's	3,413 ⁺ / 11,600 [#]
MCF's Natural Gas	Cubic Feet	1000.00
	Therms	10.00
CCF Natural Gas	BTU's	103,000
CF Natural Gas	BTU's	1,030
Therms Natural Gas	BTU's	100,000
Horsepower	KW's	.746
	BTU's/min	42.41
Barrels (bbls)	Gallons	42
Barrels Crude Oil	BTU's	5,825,000
Gallons No. 2 Heating Oil	BTU's	138,690
Barrels No. 5 Residual Fuel	BTU's	6,287,000
Barrels No. 6 Heating Oil	BTU's	6,286,980
Gallons Gasoline	BTU's	125,000
Barrels Liquified Propane Gas (LPG)	BTU's	4,009,950
Short Tons Coal	BTU's	24,500,000
Watts (W)	BTU's/hour	3.41
Kilowatts (KW)	Watts	1000.00
Pounds Steam (lbs)	BTU's	1000.00 ⁺ / 1390.00 [#]
Tons Refrigeration	BTU's/hour	12,000

* Sea level

+ Institutional Conversion Factor

Point of Generation Conversion Factor (for Federal Reporting)

TESTING EVALUATION

ENERGY 110 - MATERIALS AND DESIGN IN CONSERVATION

Name _____

1. Give ten (10) energy conservation criteria to be observed when building a home. (Be specific as possible, for instance, give R-values.)

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

2. List ten (10) places where infiltration commonly occurs and state conservation measures to stop it.

PLACE

CURE

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

3. Give three (3) types of caulk and where it is used.

TYPE

use area

_____	_____
_____	_____
_____	_____

THERE'S MORE

4. How many air changes per hour in a:

good home _____ per hour

average home _____ per hour

5. Design three (3) of your own questions and answer them on:

house design, energy efficient design, infiltration

F INAL EXAM ENERGY110 MATERIALS AND DESIGN FOR CONSERVATION JUNE 1980

Howdy folks..... This exam may appear a bit unusual from others you have had. hopefully it will encourage you to look inside and evaluate your energy awareness. At the same time you can help make this a better course next time. Please READ THE QUESTIONS CAREFULLY and KEEP YOUR ANSWERS SHORT AND TO THE POINT.

1. Of the topics covered in this course, list the three you got the most out of.
2. List the topics you would like to cover the next time this course is offered. (i.e., what wasn't covered that should have been).
3. As a result of what you have learned in this course, what plan of action are you following now to make a house/building more energy efficient this next winter?
4. How many people have you made more energy efficient in the last three months?
In what ways?

5. Think about these questions:

What have you changed about your living habits as a result of taking this course?

What have you done to use less energy?

Can you relate that to anything that has happened in this course?

Your grade is based on your performance. Performance in this case refers to how you have reduced the amount of energy you use.

Please evaluate the ACTION (S) you have taken to reduce your energy use by giving yourself a rating between 1 and 5.

- 1 = Haven't changed a bit
- 2 = Thought about it but haven't done much.
- 3 = Have begun to cut down my energy use.
- 4 = Reduced total energy consumption by at least 25%.
- 5 = Have set long-term goals and stuck with them, including recycling, planted a food garden, use automobile only when necessary, etc.

MY RATING _____

Comments:

6. You have to design a zero-energy dwelling (no ongoing use of depletable energy). Make a list of ten (10) design strategies you would use; then pick out the three most important in terms of amount of energy saved and mark them with an asterisk (*).

COURSE PROPOSAL FORM

ENERGY

130

*Course abbrev.

*Course number

Check ONE: (X) NEW COURSE PROPOSAL: complete ALL items below.
() SYLLABUS UPDATE: complete only items marked with asterisk (*).
() REVISION: specify change

*COURSE TITLE: Solar Energy Concepts

STUDENT CLASS HOURS:

33

lect.

lect/
lab.

Lab

shop

clia.

other

SYST.

3

33

35

.20

Credits

Instructor
contact hrs.

Capacity (est.)

FTEP fraction

Fee

HEGIS code:

PREREQUISITE: None

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

() academic transfer

(X) occupational preparatory

() community service

() academic basic

() occupational supplementary

() academic general

() occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

People interested in the energy field as a career, energy management technician and construction technology students.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution () ()
(transfer only) yes no

AAS electives () ()
(transfer only) yes no

AAS electives (X) ()
(15 credit yes no
block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? () (X)
yes no

CATALOG DESCRIPTION:

This course will acquaint the student with the basic technology of solar heating, the application of solar energy in the home and business, and provide background for wise decision making effecting their energy future. Physical concepts of light and heat will be presented as related to collection, storage and utilization of solar energy.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

1. Students will become more aware of their energy future, and the potential of solar energy utilization in their lives.
2. Participants will achieve an understanding of the basic nature of sunshine, and how to make good use of it through knowledge of the technologies involved.
3. Students will be equipped with information to help them make wise decisions regarding their investment in solar energy.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

1. Lecture presentation of material.
2. Discussion activities encouraging class participation.
3. Home study problems.
4. Demonstrations by instructor and/or guest lecturers.
5. No special requirements for materials, space or support.
6. One or two field trips on a Saturday may be incorporated.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

A mid-term and final examination will be given.

Students will also be required to submit a term project--design of a solar heating bldg. The building may be a new hom, a retrofit, real or fantasy. Project should include:

1. A floor plan
2. An elevation
3. A perspective
4. At least one page describing the solar system, how it is integrated into the structure, the calculations of design heat loss and solar fraction.

***GRADING:**

Grading will be based on student participation and performance on examinations.

Grading schedule:

90-100%	A
80-89%	B
70-79%	C
60-69%	D
59% or below	E

Course Standards:

Attendance	10%
Mid-term	20%
Final exam	35%
Project	35%
	<u>100%</u>

***DETAILED COURSE OUTLINE:**

TEXT: THE SOLAR HOME BOOK, Bruce Anderson, 1976

Many other sources and handouts will be used.

- I. Introduction (9/25, 27)
 - A. Energy future of the world
 - B. Solar energy's potential contribution
- II. The Solar Perspective (10/2, 4)
 - A. History of Solar building
 - B. Growth factors in the Solar Industry
 - C. Alternative Energy Sources
- III. The Energy of Sunshine (10/9, 11)
 - A. Measurement and Availability
 - B. Passive solar heating types
- IV. Energy Efficient Dwellings (10.16, 18)
Calculation and control of heat loss/gain.
- V. Passive Design Strategies (10/23, 25)
 - A. The Solar orientation of buildings
 - B. Passive solar heating types
- VI. MID-TERM EXAMINATION 20%
- VII. Principles of Collectors (11/1, 6)
 - A. Air and liquid
 - B. Flat plate and concentrating
- VIII. Storage of Solar Energy (11/8, 13)
 - A. Methods
 - B. Sizing and placement of storage
- IX. Solar System Controls and Economics of Solar Usage (11/15, 20)
 - A. Life-cycle costing
 - B. Making solar decisions
- X. Solar Electricity (11/27, 29)
Project due
- XI. FINAL EXAMINATION (12/4)

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1. _____	Course proposal form submitted to the office of the associate dean of instruction	_____
2. _____	Page one completed.	
3. _____	Division recommends approval () Division recommends disapproval ()	_____
4. _____	Reviewed by director of learning center	(DR) _____
5. _____	Reviewed by Faculty-Administration Council.	(DLR) _____
6. _____	Dean of instruction approves () Dean of instruction disapproves ()	(DI) _____
7. _____	Course proposal form filed in temporary location.	
8. _____	Pages two and three completed (prior to the end of the quarter in which taught).	
9. _____	Page four completed.	
10. _____	Course proposal form filed in permanent location.	

TEACHING METHODOLOGY

ENERGY 130 - SOLAR ENERGY CONCEPTS

CLASS I

Introduction - myself, why I am teaching this class, raising your awareness
- class participation expected

Enrollment information

Course Outline

Bibliography - other reading materials

Class project - Design your solar home

Glossary - next week, information sources NSH & CIC
P.O. Box 1607
Rockville, MD 20850
1-800-523-2929

Group Sharing -

In small groups of 3-5. Pick a leader. Each person answer the questions:

What do you do?

What is Solar energy?

Why did I choose this class?

What do I expect to find out?

Leader report to class. Introduce groups.

BREAK - 10 minutes

Energy future--Energy-use pie U.S. & World
--Shortfall - doubling - use. 5 questions.

World Energy Sources. Class generated list then discuss item in light of availability, time to get on line, who can use, cost of development, soft and hard paths.

Final hand-out

CLASS I Solar

Course outline--

Introductions--myself - why I'm teaching this class - my involvement
--class - what you do, why you're enrolled in this class

Logistics - teaching methods - ask questions freely

grading - attendance	10%
mid-term	20%
final	35%
project	35%

Go over course outline and project.

Text and other materials - Bibliography hand out

Books on Solar - Libray 1 week reserve

Periodicals - Solar Age, Solar Engineering, MENews, P.S.

Involvement - WeWaSEA, PNWSEA, AS/ISES/ISES. WEES

Information - HSH & CIC

P.O. Box 1607

Rockville, MD 20850

1-800-523-2929

Bread--

NW Energy use - hand out

Future pattern of Energy requirement - shortfall

World Energy Sources - class generated list:

availability, time to bring on line, who can use, cost of development

Films

CLASS I

To achieve energy production goals of 1975.

based on sustaining growth in energy consumption and minimizing oil imports.

coal, oil and gas (our own), nuclear fission.

unconventional given minor role until 2000

Short term growth rather than long term sustinence.

Initial investment \$1 Trillion, 70-80% for new growth of electricity, 6.5% per year

3/4 net private domestic investment has been $\frac{1}{4}$ to now.

1976-1985--900 new oil wells offshore U.S.

170 new coal mines (200MT/yr east, 120 MY/yr west)

100 new uranium mines, new enrichment plant, 40 fuel fabrics. 3 fuel reprocessing plants

180 new 300 MW coal fired stations

140 1000 MW nukes

60 conventional

100 pumped storage hydro plants

350 gas turbine plants

by 2000 --450-800 reactors each with 2.5 tons plutonium

500-800 coal fired stations

1000-1600 new coal mines

15 M electric automobiles

CO₂ doubled in atmosphere around this time.

CLASS II SOLAR

1. Roll check - new students
2. Discussion of Soft energy paths - 5 characteristics
3. Solar industry history and development
4. Book break - National Solar Heating & C. Information center 1-800-523-2929
5. Growth factors in S.E.
6. Hand out Glossaries
7. Alternative Energy forms.
Wind--
Wood--

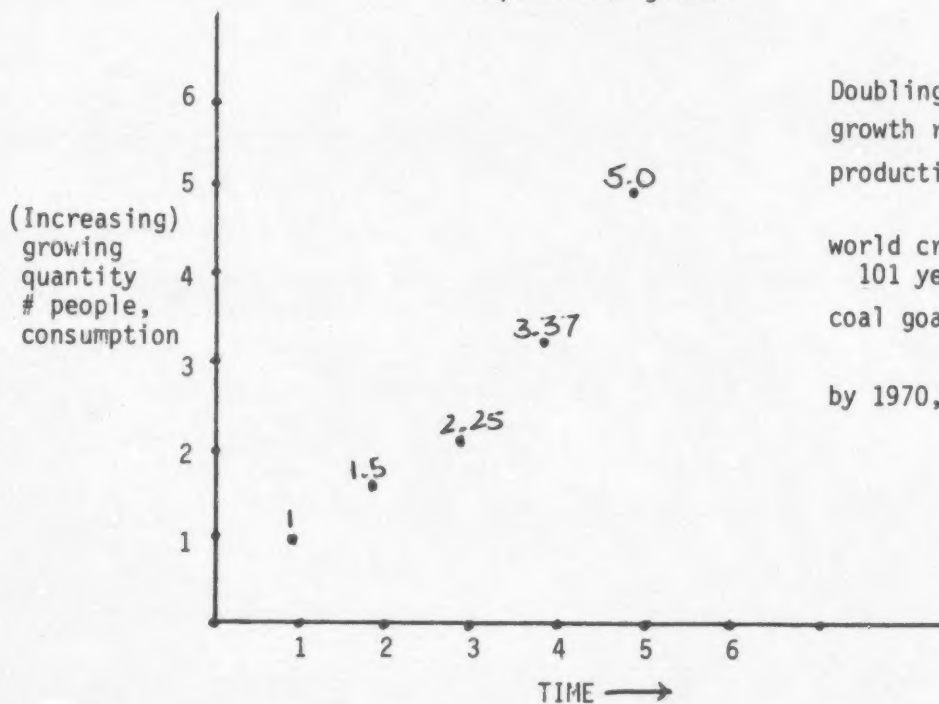
CLASS II SOLAR

1. Check roll - all enrolled? - new students introductions
Reading assignment 1-63 this week 55-62
2. 5 questions about future energy requirements.
Who is going to require the energy?
How much energy?
What kind of energy?
For what purpose?
For how long?
3. Generate list of energy alternatives (sources and forms)
4. Introduce soft energy paths and show leveling off.
5 characteristics of soft energy paths:
 1. Reliance on renewable energy flows that are always there--used or not.
Energy income rather than Energy capital
 2. Diversity - National energy supply is an aggregate of individually modest contributions designed for maximum effectiveness in particular circumstances.
 3. Flexible and relatively low technology - not unsophisticated but easy to understand and use by simple skills.
 4. Matched in scale and in geographic distribution to end use needs.
Taking advantage of most natural energy flows.
US end use Energy → 58% → Heat - 23% > boiling, 38% → motion, 4%-other
35% < boiling,
 5. Matched in energy quality to end use needs. Right tool for right job.
5. Growth and development of the Solar Industry. Read early solar houses in Text.
6. Barriers and growth factors in solar development.
7. Hand out glossaries.

* 5 questions about future energy requirements:

1. Who is going to require the energy?
2. How much energy?
3. What kind of energy?
4. For what purpose?
5. For how long?

Mathematics of Doubling:
Exponential growth



Doubling time 8.4 years
growth rate of .50%

production oil 1870-1929 8%
1970 3.29 B

world crude ann. prod. rate 16.7bb1
101 years left at 1970 rate

coal goals U.S. prod 13%
74-85 11%

by 1970, 50.8% reserves used

CLASS II

Growth factors- Barriers-

1. High cost - \$8-\$50/☒ coll.
2. Lack of clear, reliable information
3. Technical problems
4. Inadequate guarantees - related to #7
5. Poor installation - Repair personnel - inexperience
6. Utility pricing - cheap elect. in NW
7. Insecurity with small, unknown manufacturer
8. Governmental indecision - tax incentives
9. Difficulty locating parts and equipment - std. parts, simple
10. Fear of obsolete technology - simplicity
11. Unproven payback experience - confusing, many methods
12. Bank loan difficulty - Sea Trust
13. Fear of increased taxes - WA bill of 8 year non-assessment
14. Poor aesthetics
15. Vandalism - TV paranoia
16. Unsure of sunlight - PNW especially
17. Code conflicts - new energy codes
18. Antifreeze fears.

Incentives for Solar Industry.

1. Income tax credits 400 insul. 2200 solar
2. Sales tax exemption - unlikely
3. Easily available information
4. Continued Research - DOE budget increases
5. Low interest loans - ?
6. Energy information centers - WA State LBC (?)
7. Solar equipment stores
8. Training programs for repair - install persons (Now)
9. Large Company involvement - (Hard Path-Growth...)
10. Strict performance standards by the industry (not Gov't.)
11. Government guarantees
12. Sunrights laws.
13. Rental/Lease Companies

CLASS II

Characteristics of Soft Energy Paths

1. Reliance on renewable energy flows that are always there, used or not. Energy income rather than depletable energy capital.
 2. Diversity, national energy supply is an aggregate of individually modest contributions designed for maximum effectiveness in particular circumstances.
 3. Flexible and relatively low technology - not unsophisticated but easy to understand and use by simple skills.
 4. Matched in scale and in geographic distribution to end use needs. Taking advantage of free distribution of most natural energy flows.
- End use $\left\{ \begin{array}{l} 58\% \text{ of all US energy use is as Heat. } 23\% \text{ boiling, } 35\% \text{ boiling} \\ 38\% \text{ of all US energy use provides motion} \\ 4\% \text{ of all US energy use is everything else. Lights, electronics,} \\ \text{welding, appliance motors...} \end{array} \right.$
5. Matched in energy quality to end use needs. Right tool for right job.

The Solar Industry History and Development--

- First attempts at active collection 1850's Swiss.
- Basic design principles used long time. Cooling in Mid East. Directed air flow in buildings. Wind towers. SW Indians, Cliff Dwellers
- 1890's-1920's early U.S. Industry mainly in S. California and water heaters plateglass patents of collectors. Oil and gas replaced need.
- 1930's Activity moved to Florida. 40,000 water heaters
- War--completed transition to petroleum dependence
- 1939 2 solar homes Mlt - active air heaters and rock storage
Geo. Löf - Colorado Air/Rock
- 1973 Oil crisis - rebirth of S.E.
- 1976 Formation of Industry Association, etc.
growth reports ~ 56% growth
- 1977 126% boom growth
- 1978 first 4° 10% Second 4° 13%
Solar Legislation lack of tax incentives and slack
- by 1985 2.5 million homes with solar use. President's goal ('77 energy mess.
now ~ 50,000. 250 K per year!

Divisions of the Industry

- Active systems
- Passive applications
- Solar thermal
- Photovoltaic
- Controls and Distribution
- Wind systems
- Biomass-wood-recycle and mgt.
-methane

SOLAR CLASS III
Energy of Sunshine

1. roll call - all enrolled? Reading next week 62-75
2. questions and announcements - N.W. alt Energy Fair, Solar van cancelled
3. Hand outs--
 - glossary - discuss
 - basics of solar utilization
 - solar radiometer
 - sunchart

4. Measurement of solar radiation

BTU, calories	kilojoules	(radiation)Heat energy	
BTU/□, Langley ($\frac{\text{cal}}{\text{cm}^2}$)	Kilojoules/m ²	impingment on surface	
BTU/□/hr, Langley/min	KJ/m ² /hr	Watts/m ² Energy rate or Power	
1	3.69	.088	at instant in time
1	221.0	.088	.316

Solar constant - 429.2 BTU/□/hr.

What happens to it?

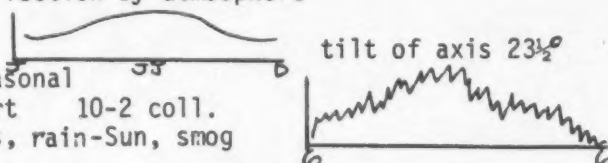
absorption and reflection by atmosphere

Annual variation

monthly and seasonal

daily - Sunchart 10-2 coll.

hourly - clouds, rain-Sun, smog



BREAK

5. Greenhouse effect
6. Basics sheet.
Collector and tilt
Space heating or water -
7. Collector orientation
8. Solar Window - altitude and azimuth

SOLAR CLASS III

roll call - student info. sheet for new enrollees introductions

questions

project report next week

how many have Solar home book - 8

Fundamentals of SH - 5

Other (Solar Heated Houses, Tudor Press, Solarian Manual, complete Solar House, Design and Building a SH by Watson)

go over glossary

The Sun - hand out notes

Spectrum - sunshine energy on earth - direct
diffuse
reflected

atmospheric effect - reflection-diffuse
- absorption-rerad. 0-75% get to earth

Units of measure:

Langley (Calories/cm ²)	3.69	>	at any instant in time
BTU/ft ²	1.0		
Kilojoules/m ²	.088	>	Energy rate or Power
Langleys/min.	221.0		
BTU/ft ² /hr.	1.0		
Watts/m ²	.316		
Kilojoules/m ² /hr	.088		

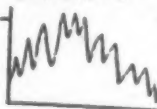
Greenhouse effect

Annual variation

Monthly/seasonal variation

Daily - sunchart - trees, buildings

hourly - clouds, rain, smog



SOLAR CLASS III

The Sun - Solar eclipse Feb. 27, 1979, 8:30-10:00 AM

Universe is system of galaxies
some with organic molecules
millions of stars

Our galaxy (Milky Way galaxy) disk shaped and spiral

Our Sun $3/5$ from center to edge.

appears to be a typical star. Next nearest Proxima Centaure, 4.25 light years

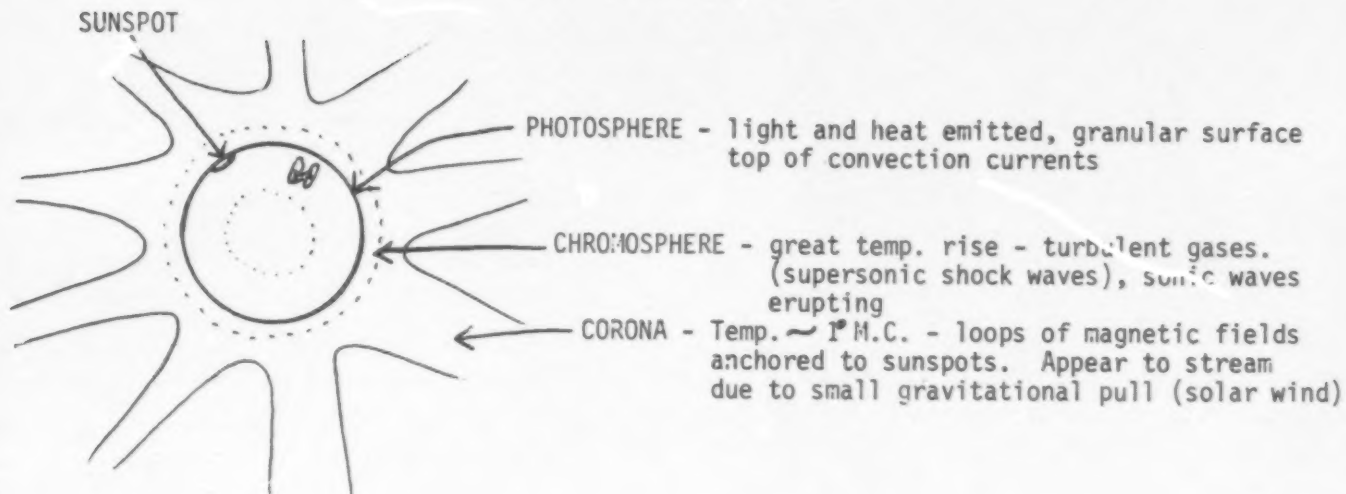
Sun is only 8 light minutes (150 million kilometers) because of its closeness, it is the ultimate support of life on Earth.

Can see surface detail of 200 km.

Sun - spherical body of gas with increasing temps. to center.

75% Hydrogen, ~25% Helium plus some other elements.

interior temperatures so high that thermonuclear fusion rx. occur spontaneously, future energy source



11 year Sun Cycle of activity - many phenomena. next max. 79-80

Sunspots - studied by Galileo in 1610, known by ancients - intense magnetism

Flares - explosions in chromosphere & corona, probably due to sunspot act., high energy particles (mostly stopped by atmosphere), aurora, E. mag. fields, radio interference. Concorde has rad. monitor

Solar output has not changed much in Earth's history. Other stars vary in output

Solar Constant - $429 \text{ BTU}/\text{hr} = 10,296 \text{ BTU}/\text{day}$

SOLAR CLASS IV

Roll and announcements Mid-term in 2 weeks - question, review next week

Solar angles, Seasonal changes, Reflection

BREAK

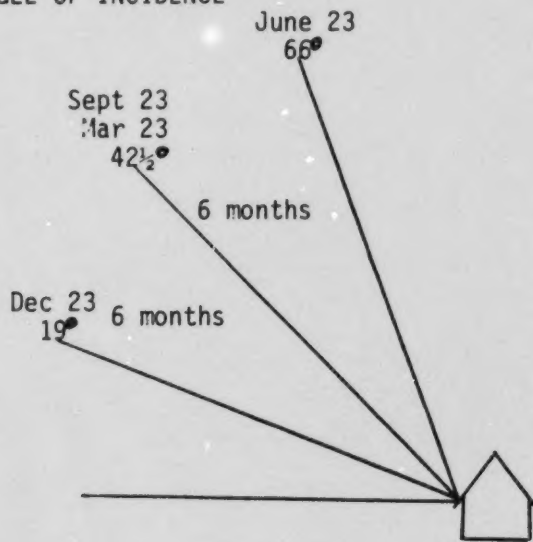
Solar orientation of buildings

Project reports and discussion of progress

Hand out Energy books

Heat - conduction - convection - radiation - sensible - Units

ANGLE OF INCIDENCE



Use sunchart to evaluate solar window - look for shadow producers. Determine alt. and azi position of sun at 10 am Oct. 21, 3 pm Nov. 21

Std roof pitches

2-12 $\approx$ 9°
4-12 $\approx$ 18½°
6-12 $\approx$ 27°
8-12 $\approx$ 33½°
10-12 $\approx$ 39½°

12-12 $\approx$ 45°
14-12 $\approx$ 49°
16-12 $\approx$ 53°
18-12 $\approx$ 56°
20-12 $\approx$ 59°

2-12 $\approx$ 61°
24-12 $\approx$ 63°

SOLAR CLASS IV

Collector tilt rule of latitude $+10^{\circ}$ - 15° best for year-round collection. For Seattle, this can be modified to summer collection for annual storage.

Use winter daily collection limited to less than 50% SF due to rain and low solar angle.

In Seattle, winter collection is frequently through vertically mounted collectors, especially Passive systems and use of reflection. Advantage of flashing in vertical collectors.

for DHW - lat -10° to lat. $+20^{\circ}$

37°(9-12) 57°(19-12)

Dec-Feb. - only ~ 3-5% from solar for DHW

Shading--

SOLAR CLASS V

Heat Transfer--

Text sources: Energy and How to Conserve it - Ken Cooper
The Solar Home Book - Bruce Anderson, pp 63-74

Heat Flow:

Heat is motion of atoms and molecules in a substance

greater heat - greater motion (vibration)

17th Century - "Phlogiston" - heat is a fluid that flows hot → cold

Heat tends to equalize (spread out) - called "flow" always hot → cold

Rate of heat flow dependent on Δt . Greater Δt , greater flow.

Quantity of heat that flows is dependent on Resistance between t_i & t_o .

In buildings we increase R to lower the quantity

3 basic methods of heat flow: Conduction, Convection, Radiation

1. Conduction - adjacent molecules bumping each other transferring vibration. Requires a material. Not in a vacuum. Solids best (molecules closest), liquids poor, gases poorest. Decrease with thickness (Twice as thick = $\frac{1}{2}$ as much heat conducted)

--Conductance - quantity of heat that will pass through a substance.

1 in 1 hour with $1^\circ F \Delta t$

$$C = \text{BTU/hr/ft}^2 / ^\circ F$$

--Resistance - opposite of conductance $R = \frac{1}{C}$

Tendency of a material to retard the flow of heat.

materials with high R are called insulation.

higher R - better insulating properties

R - value - tables - common unit

--U-value - coefficient of heat transmission.

measure of heat flow through a building section. (floor, wall, roof)

same units as conductance. BTU / hr / ft² / °FΔt

$$U = \frac{1}{R} = \frac{1}{R_1 + R_2 + R_3 \dots + R_n}$$

Amount of heat lost thru a 50 ft² wall with U value of 0.12 over an 8 hour time span when $t_i = 65^\circ F$ & $t_o = 40^\circ F$

$$H_{con} = (U) (hr) (Area) (\Delta t)$$

$$(.12) (8 \text{ hr}) (50 \text{ ft}^2) (25^\circ F) = 1200 \text{ BTU}$$

You want to know how much heat flows through given sec.

To get U-value, add up all R and divide into 1.

Calculate U-values for all exterior surfaces. Walls, windows, doors..

To find out how much heat you will have to provide to keep your house warm in coldest weather:

design temperature - Seattle 28°F coldest expected temp.

$$\Delta H_{\text{section}} = (U_{\text{section}}) (Area_{\text{section}}) (\Delta T) \quad 70-28 = 42 \Delta t$$

for 50 ft² wall with U=0.23 in Seattle

$$\Delta H_s = (.23) (50) (42) = 483.0 \text{ BTU/hr. worst case}$$

Heating requirement for heating season:

degree days - # degrees daily average temp. was below 65°F

Seattle ~5000 (figures vary between 4424 and 5200)

convert dd to d-hours by multiplying by 24. 5000 X 24 = 120,000

$$\Delta H_{\text{seasonal}} = (U) (A) (DD \times 24)$$

$$(.23) (50) (120,000) = 1,380,000 \text{ BTU seasonal, con-}$$

duction heat loss

For total building heat requirement we must include convection losses

BREAK

SOLAR CLASS V CON't.

2. Convection - movement of a substance caused by T.
 convection loop use of convection in design later.

--3 modes of convection lead to heat loss in a building:

1. air film-wind affected, window drafts
2. air gap in section (walls)
3. air infiltration through cracks & openings. Most significant heat loss. Easiest to control.

Larger gaps result in greater movement loss.

most insulation traps air in small spaces

--Calculating infiltration heat losses

- A. Air changes per hour - estimating 1, 2, or 3.

Find volume of air in house floor area X ceiling height.

ex. $1000 \text{ ft}^2 \times 8' = 8000 \text{ ft}^3 \times 2 = 16,000 \text{ ft}^3/\text{hr}$ to heat

heat capacity of air $c = 0.018 \text{ BTU}/\text{ft}^3/\text{F}$

$$H_{inf} = (\text{Vol. air to be heated/hr.}) (0.018) (t_d) \quad 70-28=42$$

$$= (16,000) (0.018) (42) = 12,096 \text{ BTU/hr required to heat air. Worst case}$$

For seasonal heating multiply by:

$$(16,000) (0.018) (\# \text{ degree hours}) =$$

$$(16,000) (0.018) (120,000) = 34,560,000 \text{ BTU/season}$$

- B. More detailed method (ASHRAE) p. 71 SHB

Uses crack length, width and wind velocity

$$H_{inf} = (C) (Q) (L) (h) (T)$$

C=heat cap. of air = $0.018 \text{ BTU}/\text{F}/\text{ft}^3$

Q=Volume of air leakage per hour, per foot of crack

L=length of crack

h=Hours.

3. Radiation - heat energy emitted by an object, usually not visible

Red hot coals or iron emits heat energy.

Light bulb filament emits heat and visible. Shorter wave length.

All bodies radiate energy.

Warmer bodies radiate more (T)

darker bodies radiate more than lighter. Flat black best

rough bodies radiate more than smooth. Surface area

Transmission of radiation depends on medium.

No loss in vacuum, slight loss in gases, high in liquid

- P. 284 SHB Absorption (α) absorptance = Ia:I ration of Solar energy absorbed to SE incident

- P. 83 SHB Emissivity (E) emittance = $R_m:R_b$ $\frac{\text{Radiation from material}}{\text{Radiation from blackbody}}$

Asphalt $\alpha 0.9$ sand 0.6α

$$\text{Reflectance (p)} = \frac{\text{reflected S.E.}}{\text{Incident S.E.}} = \frac{I_r}{I}$$

Radiation heat loss controlled by:

1. Use surfaces with low E at normal temps.
2. Use surfaces with good absorptance (α) used for heat gain
3. Materials with high reflectance usually have corresponding low absorptance thus low emittance

More about these factors when discussing collectors

HOMEWORK ASSIGNMENT: calculate both design and seasonal heat loss from your house.

HOUSE: 30 X 35 with 8' ceiling

CONDUCTION

SECTION	R	U	Area	ΔT	BTU/hr Heat Loss	Seas Hc.
Walls	14.33	0.069	890	37°	2272	7,369,200
Windows	0.58	1.72	100	37°	6364	20,640,000
Doors	1.56	0.64	50	37°	1134	3,840,000
Ceiling	22.00	0.05	1050	37°	1943	6,300,000
Floor	6.00	0.17	1050	37°	6605	21,420,000
(Conduction) Heat loss					18,368	59,559,200
$U \times A \times \Delta T =$						

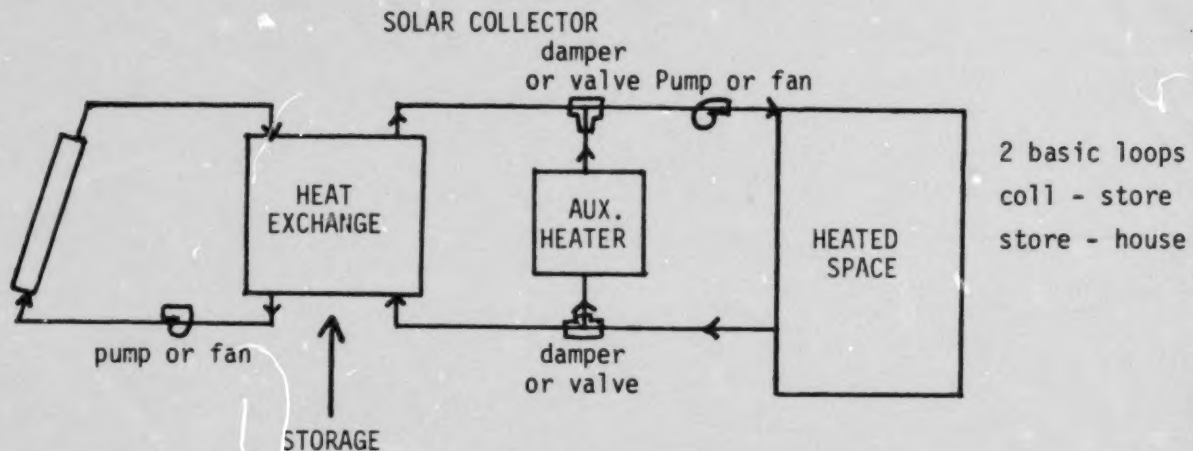
INFILTRATION

Volume of house (1 story with 8' ceiling height)	
Floor area (1050) times ceiling height (8') =	8400 cu. ft.
Air changes (Moderately leaky house)	2
Volume of air to be heated each hour	16,800 cu. ft.
Heat capacity of air	.018
$\Delta T = 65^\circ - 28^\circ =$	37° F
Heat loss (infiltration) Ac/hr X .018 X 37°	11,188
Total heat lost by conduction and infiltration	36,288,000 BTU
Seasonal H ₁ 95,857,200 BTU	18,368
	11,188
	29,556 BTU/hr

Seasonal heat loss $U \times A \times DD \times 24$

SOLAR CLASS VII

1. Hand out mid-terms and go over
2. Active systems - site built and component
 Heated fluid is transported by mechanical means to storage
 Basic components (subsystems)



Heating fluids--low thermal capacity gathers 40% more heat due to quick response
 some leakage tolerable in collector.

air - (+) simple, long lasting components, less expensive collectors
 easy with Forced air systems (retrofit), air - rock - house
 favorable heat transfer.

(-) Must move greater volume due to low heat capacity (0.018)
 water exchange loses heat, may require large, with rocks, storage cap.
 pumps may be cheaper to operate than blowers

water - (+) good for down water heaters and pools, where radiant heating used, when
 heat must be transported long distances (large buildings, etc.),
 liquid storage smaller

(-) freezes, no leaks tolerable, more expensive collectors and installation
 corrosive to equipment, water to air exchange loses.

Anti-freeze--Propylene Glycol (safe), ethylene glycol, requires double walled heat
 exchange with potable water, 2-3 year life, more expensive

Oil and freon(heat pump assist) -- used but not widely accepted

Collectors - flat-plate - an appliance - convert sun's energy into useful heat energy that is carried to storage for later use.

basic components:

glazing - single or double transmittance. Glass-low iron best-not green on edge. Plastics-Mylar, Tedlar, Teflon, lexan, green house figer-glass. Selective surfaces

absorber - usually black-maximized sunlight retention, absorptivity, reflectivity, emissivity

transport of fluid - pipes or ducts--

can (body) - durable, inexpensive, leak proof, metal, plastic, wood

inlet and outlet, (manifolds)

collector arrays - leaders, internal manifolding.

Liquid type flat plate collector - Thermosiphon or pumped

3 basic types:

trickle - flows over surface, low temp. (pools etc), self draining, ef corrugated metal. Atmospheric pressure, easy to build

tube-in-plate or sandwich type - usually aluminum or copper Roll bond

 sheets spot welded then blown up (expanded)

tube-type - cu. tubes fastened to back or front of absorber. Common water heaters, bonding to absorber critical. Good solder joint can conduct as much as 1000 BTU/hr/°F or if it isn't touching absorber. differential expansion. Some way to keep tube in good contact with absorber.

Tubing size - risers usually 3/8 - 5/8", headers, 3/4 - 1"

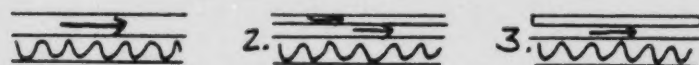
Flow pattern - must drain completely! No high spots. low pressure drop.
uniform fluid flow important to efficiency - grid and header arrang.
Serpentine pattern - greatest pressure drop.

Air type flat plate collectors - Thermosiphon and blown, convective loop

absorber - can be most anything that is sun heated - all will release heat to air and it flows over all surfaces.

lots of recycled materials (beer cans)

air flow and heat transfer -



1. heat transfer coefficient - rate that heat is transferred into air.
flow rate critical - more air, greater "h", larger surface, greater "h".

Turbulence vs. smooth flow. Forcing air to flow around (mesh, etc.)

prevention of air leakage. Solar heated air is under some pressure.
internal manifolding.

	air	water
specific heat	.24	1.0
density	.075 #/ft ³	62.5 #/ft ³
storage	3500	1

3500 ft³ air = 1 cu. ft. water

SOLAR GREENHOUSE TOUR

factors affecting sizing - p. 171-180
Collector performance - p 178 example
sizing - p 180

Storage -
Passive - p 141-146
Active - p 183-194

Factors affecting collector sizing:

1. Collector heat losses - efficiency. Amt. of sunlight converted to heat glazing (-)10% per pane, absorber temperature - higher temp (ΔT) greater loss
wind speed and rain -
amt. of insulation - 2" fiberglass or R 6-20 dep. on collector type.
2. Insulation - graph p 174 - appendix 1 p 260 S. facing only
clouds - longest period between sunny days?
3. coll. orientation and tilt. diagrams p 175-176

Collector performance - should be able to deliver 1000 BTU/ μ /winter day
monthly collector output - chart p 179

Collector size - p 180 go through chart and example

STORAGE

Heat Storage - heat needed when sun isn't shining

How materials store heat: p. 184

specific heat - # of BTU required to raise 1 lb. of material 1 F

density - pounds per ft³

SH x D = Heat capacity (BTU/ft³/°F)

heat recovered as storage loses temp.

latent - melt→solidify - phase change
freeze

needs melting point at favorable temp. for use.

salts - e.g. glauber's salt absorbs 104 BTU/lb @ 90°F

paraffin absorbs 65 BTU/lb.

Chemical - Uses solar energy to produce chemicals - H₂O→Hydrogen + O₂
Methanol H₂SO₄ conc.

Water - tanks for active systems 1-10 gal/ft³ coll.

heat capacity of 62 BTU/ft³/°F 1 ft³ = 7.48 gal.

problems: cost of containment - good tanks are expensive
plastic lined concrete, ground, fiberglass
corrosion -

direct loop vs. heat exchanger coil immersed (anti freeze)
tank in rocks.

water in passive systems -

beneath plenum - jugs, waterbed,

inside room - anywhere absorbs heat - adds thermal mass

direct transfer of energy 55 gal

water walls - drums, 5 gal cont., columns. 3 Gal H₂O/ft² glazing

if container is thin, consider voids

if tank, no voids

> R value of container material

Rocks for Heat storage -

specific heat 0.21 BTU/lb/°F Density 170 #/ft³ heat cap. 36 solid

large bin 80-400 lbs/ft³ coll + 30% voids for container size

2½ times more volume than H₂O for same heat storage.

3/4-4" round rocks. Good heat transfer surface with air.

Placement of large bin - and bin size regulated by site.

Underground bins - insulated sides. Larger bins

framed bins - at or near surface - smaller bins

std. shipping container 8' X 10" X 20" = ~70 tons rock.

horizontal flow bins - under floor - heat recovery by radiat

heating a bin - Top dump - stratification - smaller bins

bottom dump - long term, annual storage - large bins

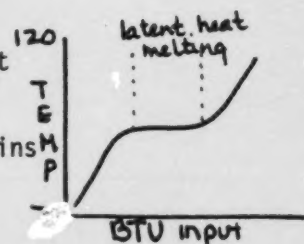
Eutectic salts - (low m.p.) p. 190

latent heat storage

good for low temp. storage up to 100 F

1 lb. glauber's salt = 4 lbs. water = 20 lbs. rock for 125 BTU over same temp. rise

smaller storage definite advantage e.g. location. Future, promise



Entectic salts con't.

high cost - 20-30 cents a lb.
 limited availability now - trays, sacks
 Dow Thermal Batteries?
 Sodium Sulfate decahydrate
 Calcium Chloride hexahydrate

Sizing the storage - several theories. Annual, short term

The higher the temp. the smaller the storage and less efficient collection
 linked to collector temp. and heat dist. system.
 upper limit of storage temp. determined by collector performance
 lower limit of storage temp. determined by heat dist. system.

Capacity of storage often expressed as # sunless days it will keep the house warm.
 2 days storage, etc. (different in Jan. and April)

At the smallest, storage should be capable of storing all heat that can be collected on a sunny January day.

Estimating the storage size: (140°)

1. determine max. storage temp (max. coll. op. temp- 5 F)
 determine min. useful temp e.g. 85° F
 $135^{\circ} - 85^{\circ} = 50^{\circ} \text{F } \Delta T \text{ stor.}$

2. determine how much heat can be stored in 1 ft³ at ΔT stor.

$$\text{H}_2\text{O specific heat} \times \text{density} \times \Delta T_{\text{stor}} = 3120 \text{ BTU/ft}^3 \text{ (417 BTU/gal)}$$

$$\text{rock } .21 \times 170 \times 50 = 1785 \text{ BTU/ft}^3$$

3. If you can gather 1000 BTU/ft² coll. on sunny winter day, then you need:
 $1000 \div 3120 = .32 \text{ ft}^3/\text{ft}^2 \text{ coll}$
 $1000 \div 1785 = .56 \text{ ft}^3/\text{ft}^2 \text{ coll}$

4. for 277.5 ft² coll. = $277.5 \times .32 = 88.8 \text{ ft}^3 \text{ H}_2\text{O storage}$
 $277.5 \times .56 = 155.4 \text{ ft}^3 \text{ solid rock} + 201.5$

5. Determine BTU stored - $88.8 \text{ ft}^3 \times 62 \times \Delta T = 275,280 \text{ BTU}$
 $155.4 \times 36 \times \Delta T = 279,000 \text{ BTU}$
 $201.5 \times 25 \times 50 = 251,875 \text{ BTU}$

6. calculate house heating demand and adjust storage size to suit

Water wall storage - 100 ft² glazing
 greenhouse - 100 ft²

1. lowest useable stor. - 65° $95^{\circ} - 65^{\circ} = 30^{\circ}$
2. $1.0 \times 62.4 \times 30^{\circ} = 1872 \text{ BTU/ft}^2$
 $.21 \times 170 \times 30^{\circ} = 1071 \text{ BTU/ft}^2$
 1478 BTU/ft² vertical surface on Jan. sunny day.
3. $500 \div 1872 = .27 \text{ ft}^3/\text{ft}^2 \text{ glazing}$
4. $100 \times .27 \text{ ft}^3/\text{ft}^2 = 27 \text{ ft}^3 \text{ for gh. } 202.5 \text{ gal}$
5. $27 \text{ ft}^3 \times 62 \times \Delta T(30^{\circ}) = 50,220 \text{ BTU}$
 $37.5 \times 36 \times 50 = 69,750 \text{ BTU } 281.25$

1. Determine temp range
2. Determine how much heat can be stored in 1 cu. foot at ΔT stor.
- per 3. Determine necessary size to store all collectable on Jan. sunny day.
- for coll. 4. "
5. Determine BTU's stored.
6. Adjust stor. size to house heating demand

SOLAR CLASS IX
Life cycle costing

LCC an estimating method that accounts for future costs (energy consumption, maintenance and repair).

our present low down - monthly payment economy is deliberately misleading in order to sell more.

In solar with apparently high front end costs we need to find out how much system will cost over a number of years (life cycle)

Initial cost (known) + life time expenditures (Pe)

$$Pe = A \frac{R(R^n - 1)}{R - 1}$$

A=current expense, n=# years in life

$$R = \frac{1+g}{1+i}$$

i=interest rate

g=inflation rate

cost of oil = .60/gal g=10%/yr. n=30 yrs.

SOLAR ECONOMICS

Home heating not considered an investment today. Should be.

Cost and benefits played down.

Chapter 8 S.H.B.

Heat house as cheaply as possible--

Alternatives:

1. freeze
2. "Conventional" heating system
3. "Solar"

Front end cost main decision factor up to now.

Investment criteria.

Net lifetime benefit.

lifetime of user use, not equipment.

costs:	O & M	first cost	Mortgage	Dividends	Salvage	Satisfaction
convent.	✓					
solar	✓	✓	✓			
freeze				✓		
conservation					✓	resale

benefit/cost--
payback--

SOLAR CLASS X

WHERE FROM HERE...

Training programs - go through

O.J.T. do one - your own then others

Dealer - minimum inventors, installation and design training

Distributor - stocking inventory \$100,000 and up

jobs - builders of solar homes

SUPPLEMENTAL INSTRUCTIONAL MATERIALS

ENERGY 130 - SOLAR ENERGY CONCEPTS

COURSE OUTLINE

SOLAR ENERGY CONCEPTS

ENERGY 130

PERRY LOVELACE

- I. Introduction (9/25, 9/27)
 - A. Energy future of the world
 - B. Solar energy's potential contribution
- II. The Solar Perspective (10/2, 10/4)
 - A. History of Solar Building
 - B. Growth factors in the Solar Industry
 - C. Alternative Energy Sources
- III. The Energy of Sunshine (10/9, 10/11)
 - A. Measurement and Availability
 - B. Solar angles, seasonal changes, the solar window
- IV. Energy Efficient Dwellings (10/16, 10/18)
Calculation and control of heat loss/gain.
- V. Passive Design Strategies (10/23, 10/25)
 - A. The Solar orientation of buildings
 - B. Passive solar heating types
- VI. Mid Term Examination (10/30)
- VII. Principles of Collectors (11/1, 11/6)
 - A. Air and liquid
 - B. Flat plate and concentrating
- VIII. Storage of Solar Energy (11/8, 11/13)
 - A. Methods
 - B. Sizing and placement of storage
- IX. Solar System Controls and Economics of Solar Usage (11/15, 11/22)
 - A. Life-cycle costing
 - B. Making solar decisions
- X. Solar Electricity (11/27, 11/29)
Project Due
- XI. Final Examination (12/4)

TEXT: THE SOLAR HOME BOOK , Bruce Anderson, 1976

Many other sources and handouts will be used.

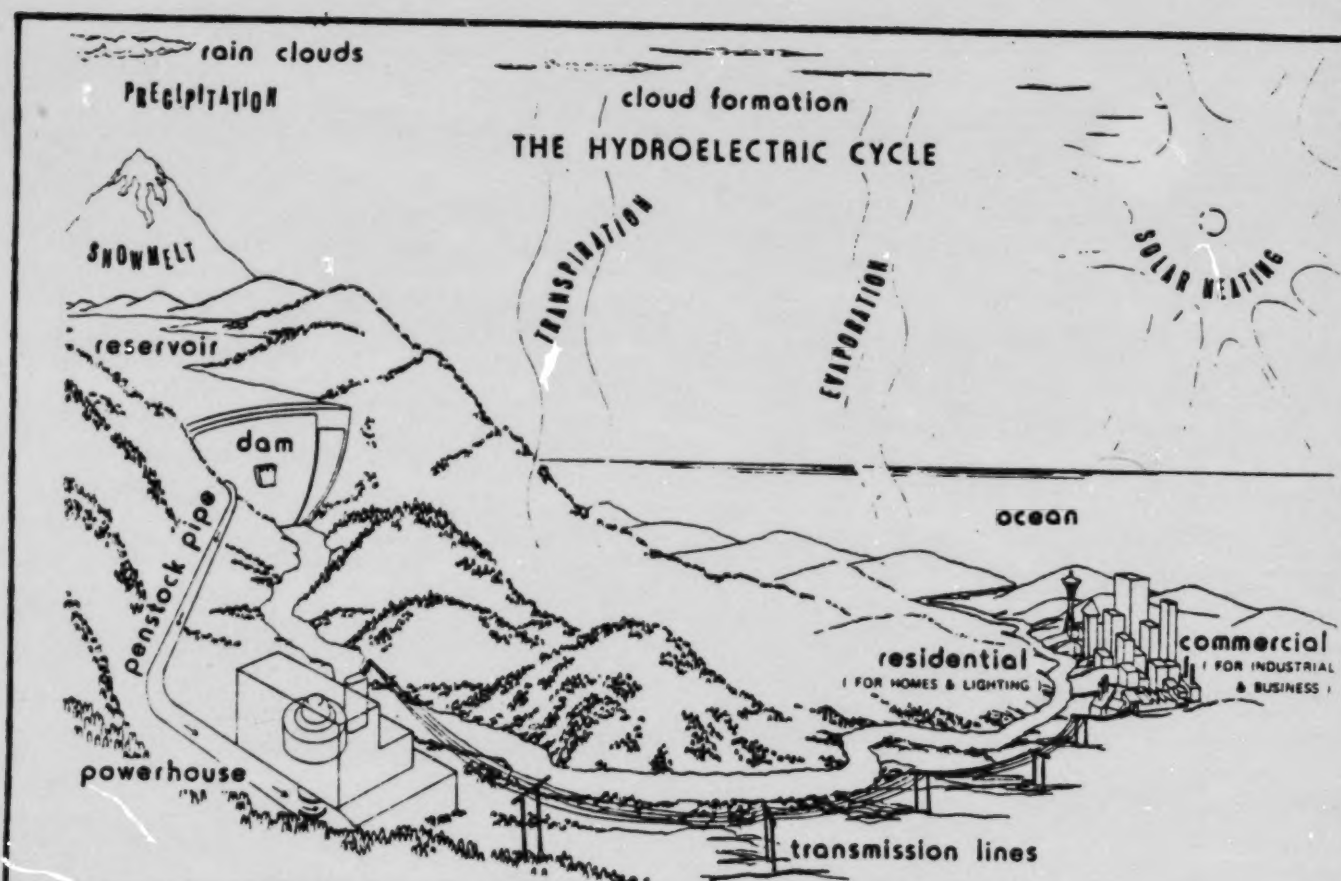
PROJECT: Design a solar heated building

The building may be a new home, a retrofit, real or fantasy.

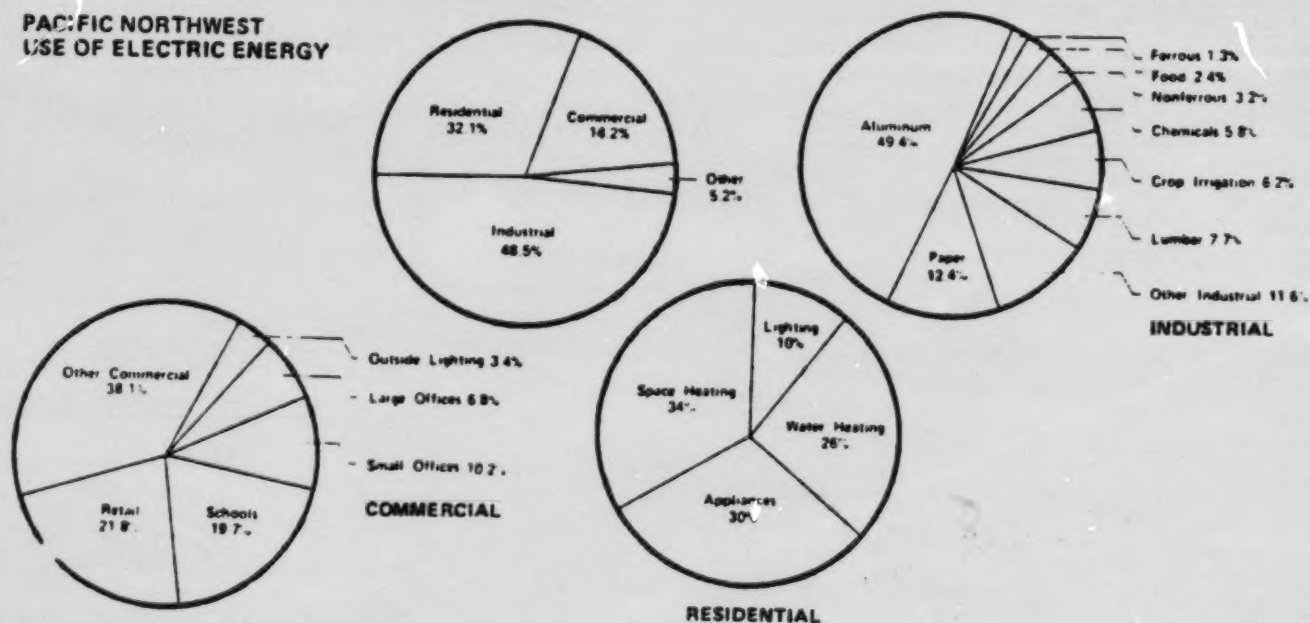
Project should include:

1. A floor plan
2. An elevation
3. A perspective
4. At least one page describing the solar system, how it is integrated into the structure, the calculations of design heat loss and solar fraction.

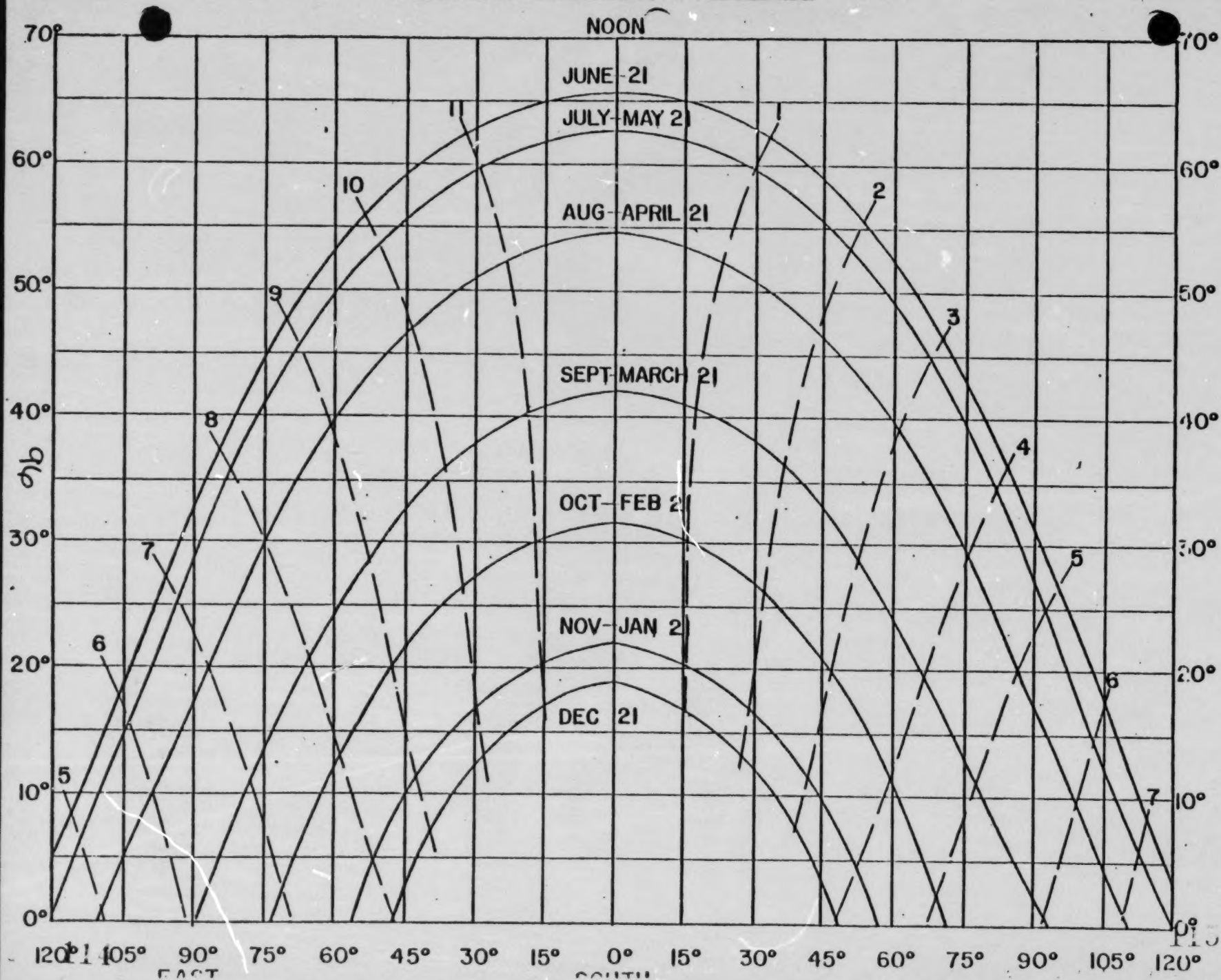
Energy In The Evergreen State



PACIFIC NORTHWEST USE OF ELECTRIC ENERGY



70° NORTH LATITUDE SUN CHART



SEATTLE-TACOMA, WASHINGTON
47° 27'

19-year averages

BTU/SQ. FT./DAY

on horizontal surface

Insolation on south-facing surfaces

Reflectivity from ground, roof assumed at 20%

		Horiz.	15°	30°	45°	60°	75°	Vert.
January	Direct	112	204	282	341	377	387	370
	Diffuse	169	166	157	144	127	106	84
KT = 0.30	Reflected	0	1	4	8	14	21	28
	TOTAL	280	370	443	493	517	514	483
February	Direct	288	440	562	646	685	678	625
	Diffuse	261	256	243	223	196	164	130
KT = 0.38	Reflected	0	2	7	16	27	41	55
	TOTAL	549	699	813	884	908	883	810
March	Direct	578	746	881	918	911	844	716
	Diffuse	398	391	371	340	298	250	199
KT = 0.46	Reflected	0	3	13	29	48	72	98
	TOTAL	977	1140	1245	1287	1259	1167	1015
April	Direct	875	980	1021	998	908	754	585
	Diffuse	548	539	512	468	411	340	274
KT = 0.49	Reflected	0	5	19	42	71	105	140
	TOTAL	1423	1524	1552	1508	1389	1204	999
May	Direct	1220	1254	1218	1110	935	706	448
	Diffuse	642	631	599	548	482	404	321
KT = 0.53	Reflected	0	6	25	55	93	138	186
	TOTAL	1862	1891	1842	1712	1510	1248	955
June	Direct	1241	1229	1156	1019	826	590	334
	Diffuse	698	686	651	596	523	439	349
KT = 0.52	Reflected	0	7	26	57	97	144	194
	TOTAL	1939	1922	1833	1672	1446	1173	877
July	Direct	1448	1458	1392	1247	1029	755	449
	Diffuse	643	632	600	549	482	403	321
KT = 0.58	Reflected	0	7	28	61	105	155	209
	TOTAL	2091	2097	2020	1856	1615	1314	979

Reflectivity from ground, roof assumed at 20%

		Horiz.	15°	30°	45°	60°	75°	Vert.
August	Direct	1135	1227	1243	1180	1041	837	582
	Diffuse	569	559	530	485	426	358	284
	KT = 0.55 Reflected	0	6	23	50	85	126	170
	TOTAL	1703	1791	1796	1715	1553	1321	1036

September	Direct	785	958	1066	1102	1062	950	774
	Diffuse	443	435	413	378	332	279	221
	KT = 0.52 Reflected	0	4	16	36	61	91	123
	TOTAL	1228	1398	1496	1516	1456	1320	1118

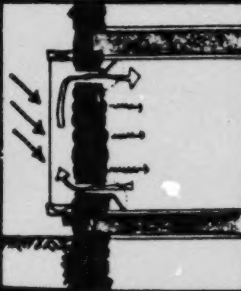
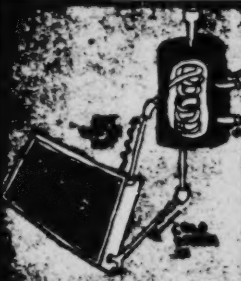
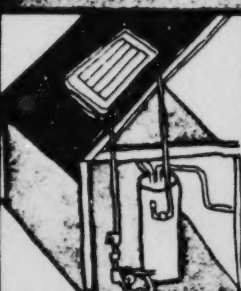
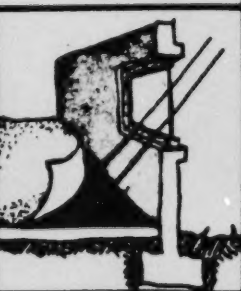
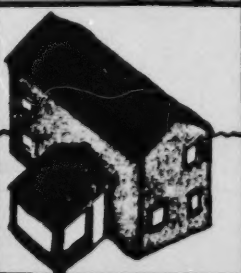
October	Direct	414	596	737	828	862	838	757
	Diffuse	301	296	281	257	226	190	151
	KT = 0.44 Reflected	0	2	10	21	36	53	72
	TOTAL	715	894	1028	1106	1124	1081	979

November	Direct	183	320	435	520	569	580	552
	Diffuse	189	186	176	161	142	119	94
	KT = 0.36 Reflected	0	1	5	11	19	28	37
	TOTAL	372	507	616	692	730	727	683

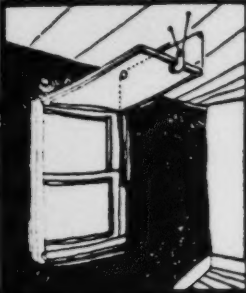
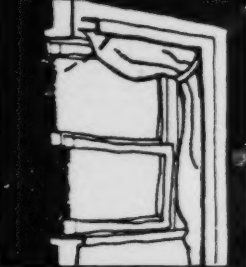
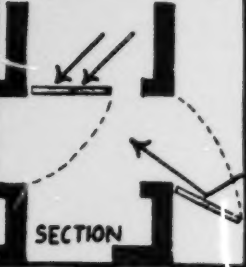
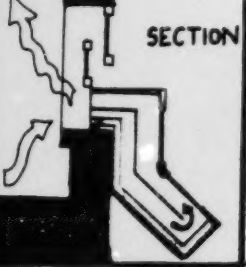
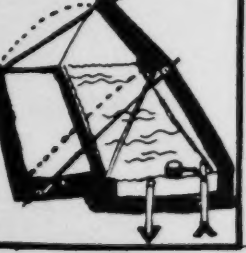
December	Direct	88	173	246	302	337	350	338
	Diffuse	144	141	134	123	108	91	72
	KT = 0.29 Reflected	0	1	3	7	12	17	23
	TOTAL	232	315	383	431	457	457	433

AVERAGE DAILY TOTAL INSOLATION FOR SPECIFIC PERIODS (BTU/SF/DAY)
SEATTLE-TACOMA, WASHINGTON

<u>DEC-JAN</u>	256	343	413	462	487	486	458
<u>NOV-MARCH</u>	482	605	698	755	772	747	683
<u>OCT-APRIL</u>	649	777	867	913	910	861	767
<u>MAY-SEPT</u>	1767	1822	1799	1696	1517	1276	992
<u>ALL YEAR</u>	1118	1215	1258	1241	1165	1035	861

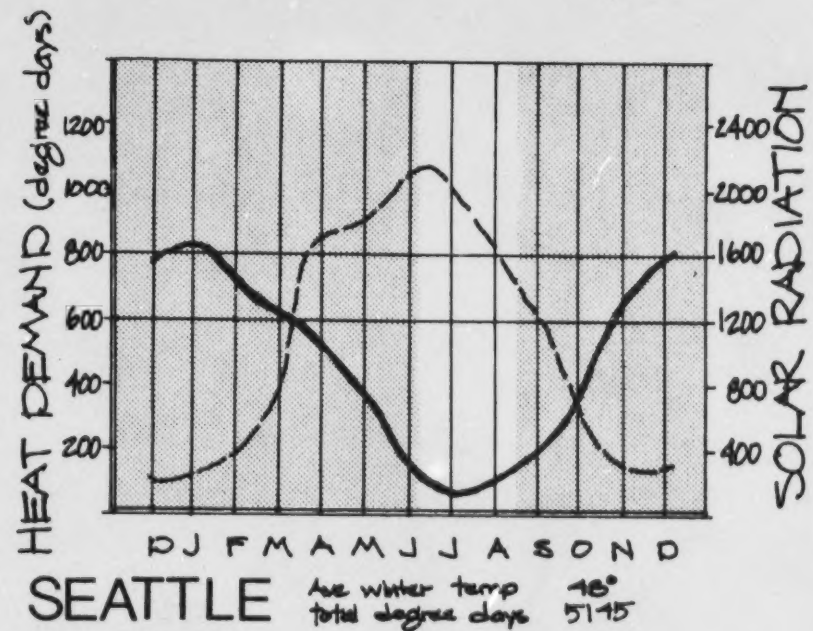
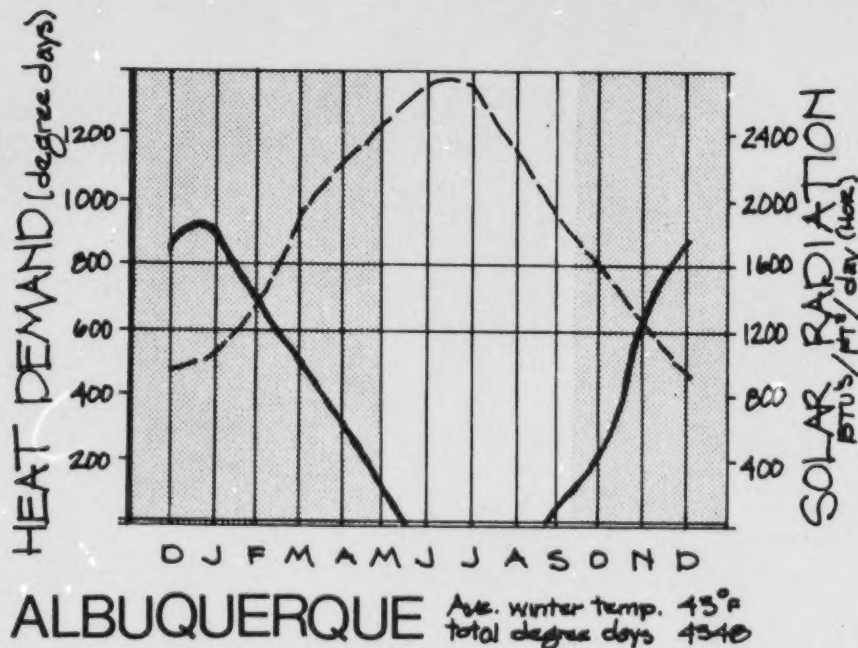
TYPE OF RETROFIT	DESCRIPTION	APPLICATION	ADVANTAGE	DIS-ADVANTAGE
	Trombe Wall Added to Existing Masonry Wall - The masonry wall is painted black, vent holes are cut into the wall at floor and ceiling level and a glazing material is placed six inches away from the wall, enclosing the wall and the vents. Solar heat is trapped by the glazing and is absorbed by the black wall. The air between the glazing and the wall heats up and rises into the room through the top vents. Cooler room air is pulled into the lower vents and is heated. The vents are closed at night with dampers and insulating shutters can be used over the glazing to keep the wall warm. (Shutters not always necessary.) Heat stored in wall radiates to room during the night. A wall collector will deliver 32-40% of the incident sunlight into the room as heat. (30-35% from circulating air, rest as radiant heat.) Variations: A frame wall may be stripped down and filled in with bricks or water barrels to achieve the same effect.	This type of collector can be added to any solid, uninsulated, south-facing wall of brick, stone or adobe. It is very easy to design into new construction.	Wall serves as a heater as well as a structural part of the building. Very simple to construct - takes one week-end; Has effective collection, storage and distribution systems that can be easily controlled; Can be installed over windows.	Collector will not work effectively over insulated or hollow walls; Appearance may be objectionable; When installed in new construction, it may take a year for the mortar and bricks to dry out and begin operating at full efficiency. Heat may damage a poorly constructed wall.
	Thermosiphoning Solar Hot Water Heater This system consists of flat plate solar collector panels, a water storage tank and a heat exchanger inside the tank. Anti-freeze solution circulates between the heat exchanger and the collectors. The sun warms the solution at the collector and causes it to rise into the tank which is mounted 2 feet above the collectors. The solution gives up its heat to the water in the tank through the heat exchanger, cools off and sinks back down to the collector.	This water heating system may be used anywhere there is a good southern exposure and a high place to mount the tank.	More efficient collector than a batch heater; Will operate automatically with little attention; Can be built from standard plumbing parts.	Complicated design requires a knowledge of plumbing; Leak in heat exchanger can pollute the hot water supply; Heavy tank mounted in attic must have adequate structural support.
	Pumped Solar Hot Water Heater Same basic components as thermosiphoning heater except the storage tank can be mounted below the collectors and an automatically controlled water pump causes the anti-freeze solution to circulate between tank and collectors. Collectors can be allowed to drain at night, thereby eliminating the need for anti-freeze and heat exchanger.	Same as other water heaters.	Very efficient solar heat collection; Automatic operation; More adaptable design.	Operation depends on electric power source; Design and controls are relatively complicated and require knowledge of plumbing and electricity.
	Greenhouses Greenhouses range in size from the small window mounted planters to the large units that cover the entire south wall. Window mounted units gain no more heat than an ordinary window and do not store heat for night time use, but do supply growing space for flowers and food. Large greenhouses stocked with water barrels for heat storage can supply a generous amount of heat to a home in a manner similar to a Trombe wall. Substantial amounts of food and living space can also be provided by a greenhouse. Recent estimates (2) indicate that food and heat savings will cause an owner-built greenhouse to pay for itself in under 2 years. It is possible to grow \$1.50 worth of food/square foot/year or more.	Greenhouses can be built on the south side of any building that has a few feet of yard space adjacent to the wall and is not shaded. Temporary plastic greenhouses work very well adjacent to mobile homes. Heat can be transferred into the house through open doors and windows and can be stored for night time use in masonry or water barrels.	Greenhouse produces heat, food, space and humidity. Greenhouses are warm, green, and aesthetically pleasing.	A productive greenhouse requires daily attention; Moisture control can be difficult in some situations. Construction requires basic carpentry skills.
	Add Thermal Mass to Sunny Rooms If you already have a lot of south facing glass on your house and the south rooms tend to overheat, the addition of cement floors, veneer brick walls or water barrels can help to store this heat and to control the temperature.	Thermal mass can be added to any south-facing sunny room, greenhouse or sunporch to improve its performance. Mass added to non-sunny room will also help to control temperature fluctuations in these rooms.	Mass will store excess heat that might ordinarily be vented; Will prevent sudden and uncomfortable temperature changes automatically and silently.	Thermal mass occupies living space and weighs quite a bit, requiring adequate structural support.
	Glassed in South Vestibule Entrance - A vestibule entrance can be built to cover the south door and can double as a sun porch or greenhouse. It will reduce heat loss when the door to the house is open and will supply solar heat as well. An unglazed vestibule entrance on the other sides of the house will greatly reduce air infiltration losses when those doors are in use.	Any entrance used during the winter would benefit from a vestibule; all that is required is the yard space adjacent to the door.	Reduced heat loss and increased heat gain; Increased living space; good opportunity to improve the appearance of the house.	Heat distribution to house may require a fan and duct; Porch structure may shade other parts of house; Generous building skills required.

NOTE: THINGS TO ASK AMERICAN FOR DIAGRAM IDEAS!

TYPE OF RETROFIT	DESCRIPTION	APPLICATION	ADVANTAGE	DIS-ADVANTAGE
	Rigid Insulating Window Shutters (Indoors) This is a window enclosure usually made of 1-2 inch styrofoam that is placed over a window at night and removed during the day. It reduces conduction and infiltration heat loss very effectively. It can be hinged, clipped or on roller tracks.	Most appropriate to icy climates that would interfere with outdoor shutters. There must be room near the window to store the shutter during the day.	Easy to make; Does not need to be weatherproof; Very effective in reducing heat loss.	May increase water condensation inside window and around frame; May be fire hazard; May interfere with furniture and living space
	Double Glazing An additional layer of glass or plastic over an existing window increases its insulating value and reduces heat loss out the window at night without eliminating the sunlight gained through the window. Extra glazing layers can be either temporary or permanent with or without wooden frames. They should be installed with weep holes so that condensation can drain out the bottom.	This idea should be applied to all windows in cold climates—especially north windows.	Inexpensive; Effective; Easy to install.	Requires seasonal attention to install and remove; May interfere with ventilation and view through window; Storm windows require summer storage space
	Insulating Window Curtains (Inside) A window curtain made of heavy drapery material that fits tightly against the top, bottom and sides of the window will prevent room air from passing against the window at night and can be opened for solar gain during the day. This will prevent heat loss without reducing solar heating. Variations: Curtains may open sideways or roll up. They may be fastened around the edge of the window with velcro, multi-layered with flexible foam inside.	This curtain can be used on any window that has enough room around the edge.	Easy to install and use; Conventional appearance; Long lifetime.	Homeowner must be willing to open and close curtains daily; Takes up wall space when open; May cost more and be less effective than rigid shutter
	Outside Insulating Window Shutters These shutters are designed to operate much like the inside rigid insulating shutters and can be just as effective at reducing heat loss. They can be designed with reflective surfaces that increase solar gain through the window during the day. They can also be used to shade the window during the summer.	Can be used on any window. Especially effective on north or shaded windows.	Shutters are effective in reducing heat loss and increasing heat gain; Can easily be constructed.	Outside shutters must be rugged enough to withstand wind, ice, falling snow and direct sunlight. Must be operated every day to be effective in bad weather.
	Window Box Air Loop Solar Collector This is basically a flat plate solar collector that is attached below an existing window. The heat of the sun striking the collector causes room air to circulate through the collector and return through the window at a higher temperature. The best solar collector is a south facing window that is insulated at night. This collector increases the heat output of any existing south window.	This collector can be added to any south facing window that has enough room below it. Can be constructed of any insulated building material and glazed with glass or plastic. Black absorber plate should have a 2" air space on both sides for air circulation.	Collector can be built from salvaged materials; Simple to install and operate; No moving parts. The point where the collector meets the window should be well sealed and insulated.	No heat storage capacity; No heat delivered to house at night; Less efficient collector than insulated window; may have undesirable appearance
	Solar Hot Water Batch Heater (Trough Type) This is basically an open tank of water that is completely surrounded by insulation. Sunlight is reflected into the enclosure through the south glazing and heats the water. The tank is filled in the morning and the heated water is used in the afternoon. The glazing is covered with insulation at night. This unit can heat roughly 1 gallon of water per square foot of glass. Variations: Batch heaters can also be built	Can be used as heater or preheater in series with a conventional water heater. Can be filled and drained manually or water level can be controlled with a float valve. Should be mounted on roof for gravity drain.	Unit will supply free hot water on sunny day all year; Can be built from salvaged materials.	Heater requires daily attention during freezing weather; Is inefficient collector

* out of old water heater tanks painted black and placed in an insulated enclosure. Sunlight can be reflected onto the tank during the day. No float valve is necessary.

Is Solar Utilization Feasible In The Northwest ?

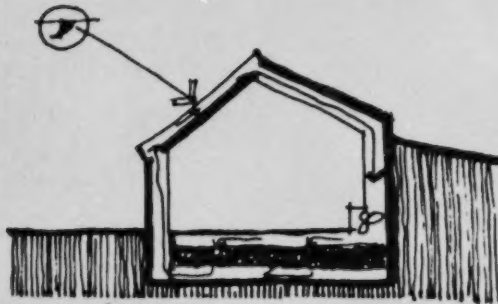


It may seem hard to believe with our cloudy winters that solar heating is feasible in the northwest. The two charts show weather data for two locations, Seattle and Albuquerque, New Mexico. Albuquerque is considered to be one of the best areas in the nation for solar utilization. The average winter temperature in Albuquerque (43) is several degrees colder than in Seattle (48). The solid line on the charts represents heating demand while the dashed line represents available solar energy. The charts show that Albuquerque has a greater heat demand in January, however the heating season (shaded area) is shorter than in Seattle.

Albuquerque has abundant solar radiation throughout the year; enough to provide 80-90% of the annual heating load. Seattle's solar availability is limited November through January but as February progresses more energy is available and by March it is abundant. This means that Seattle's mild though long heating season makes solar utilization feasible because late winter, spring and fall solar energy can provide significant (50% annually) amounts of heat.

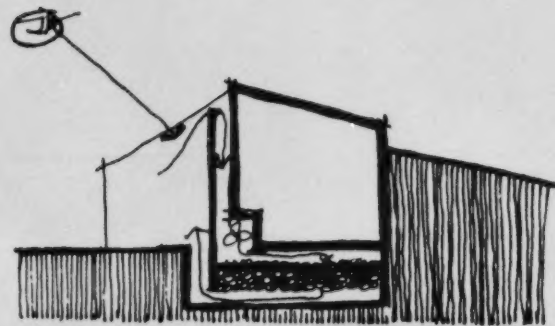
SOLAR SPACE HEATING TYPES

ACTIVE



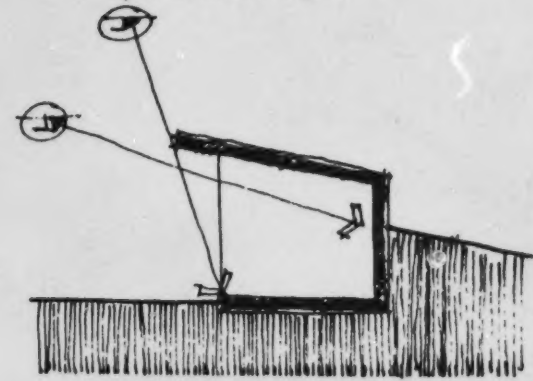
A system where the thermal energy is transferred from a remote collector and transferred by mechanical means to storage & the space to be heated.

HYBRID

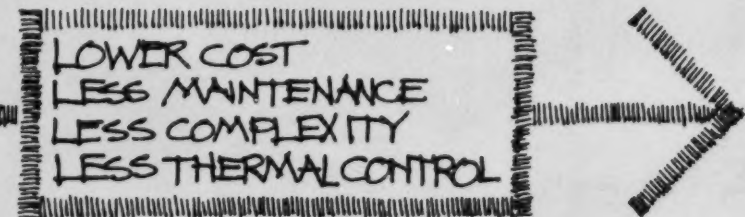
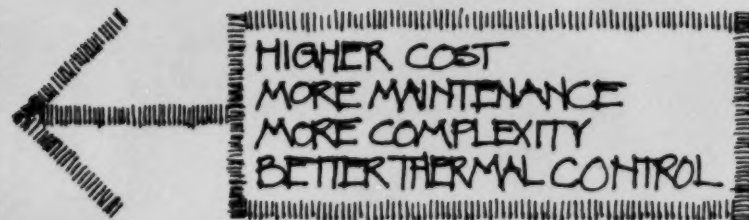


A combination of active & passive systems; such as a greenhouse used in conjunction with a fan forced rock bed for thermal storage.

PASSIVE



A system where the thermal energy is transferred by natural means; therefore there are no pumps or fans.



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123

122

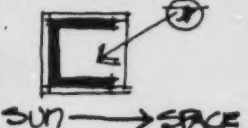
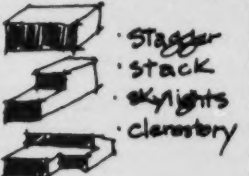
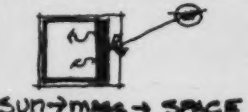
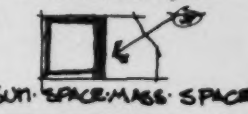
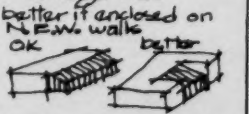


BALANCE ASSOCIATES

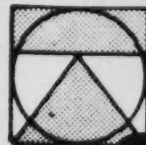
(206) 325-4500

201 Summit Ave. East, Seattle, Washington 98102

PASSIVE SOLAR HEATING TYPES

	type	form	glazing*	mass	benefits	draw-backs
direct gain	Direct Gain 	 • stagger • stack • skylights • clerestory	- 20% to 25% of floor area in south glass	- Masonry diffuse sunlight over 4' (min) walls & floor - H ₂ O (in direct sunlight) - 1 FT ³ H ₂ O to 1 FT ² glass (min)	South Glass can serve 4 functions: 1. heat 2. light 3. ventilation 4. view	• may have high temp fluctuation • glare • UV degradation of materials • building has to be masonry or have H ₂ O storage
	FREESTANDING GREENHOUSE 	 • elongate E→W • min. glazing E.W.N. walls • insulate to R-11 • reflective North ceiling	- As required for plant growth - min. glazing east west north walls & north roof	- Masonry 8" min & add H ₂ O as needed H ₂ O 3 gal / ft ² gl.	100% SOLAR HEATED IN WASHINGTON	• low CO ₂ content in greenhouse • phototropism (plants growing towards light)
indirect gain	THERMAL STORAGE WALL 	 • elongate E→W • limited to 20" depth for radiant heat	- Masonry Wall - 50% to 60% - H ₂ O 45% to 55% of floor area in south facing gl.	- Masonry 12" thick (min) H ₂ O 6" thick (min) - 1:1 glass to storage surface	- good thermal response - buildg can be light frame construction - if masonry is used for mass it also can function as structure	can restrict view south
	ATTACHED SUN SPACE 	 • elongate E→W • similar to thermal storage wall • better if enclosed on N.E.W. walls OK	- 80% to 40% of floor area in south facing glazing	- Masonry 12" (min.) thickness H ₂ O 6" thick (min) - .67 ft ³ for 1 ft ² of south gl.	- added space - excellent retrofit - other benefits similar to thermal storage wall	• large area needed to provide significant heating • large temp. fluctuation in sunspace • problems similar in sunspace to direct gain
	CONVECTIVE LOOP 	 • collector must be below space to be heated	- 30% to 60% of floor area in south facing collector	Dependent on system	Remote collection of heat therefore the space temp. doesn't have to fluctuate	added cost of collectors

101



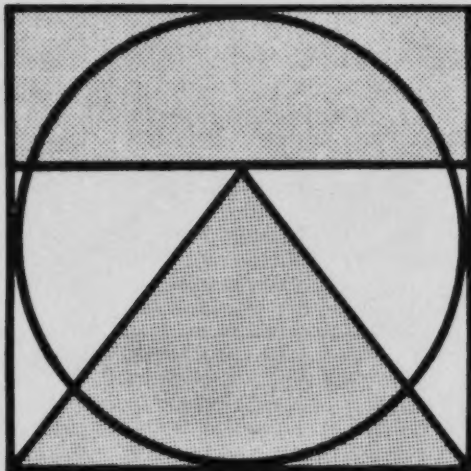
BALANCE ASSOCIATES

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* for 50% annual solar heating

125



balance associates

An interdisciplinary partnership whose intent is to bridge the gap between energy conservation theory and practical implementation in energy conserving building.

services

Our staff can assist you in a wide range of services to insure energy conservation in your building. These services include:

SITE PLANNING

- site selection
- solar and environmental planning

DESIGN

- complete design services from schematic design through construction documents
- thermal analysis

CONSTRUCTION

- construction supervision
- consulting for owner-builders
- licensed and bonded general contracting

We encourage individuals, owner-builders, builders and other professionals to take advantage of this service of design/building continuity.

3) The Complex Case (Reality)

All of our calculations up to this point have been based upon the steady state equations, where nothing is allowed to vary. In reality, we need to be able to calculate the energy balance under conditions where the temperature changes almost constantly. This requires calculating the instantaneous balance from moment to moment, and summing over time.

Fortunately, a few basic assumptions or approximations make this a relatively simple process.

They are:

- 1) that temperature changes occur smoothly and slowly. This means that it is not likely to be 50°F one minute and 0°F the next. Scientists often use a sine curve (a horizontal S curve) to represent this type of smooth shift;

2) that the monthly averages are representative of the sum of each of the separate days of that month. This might not be valid if we were interested in predicting the temperature on a specific day, but is legitimate for estimating monthly energy needs;

3) that we disregard any heat storage in the building; and

4) that heat losses are a linear function.

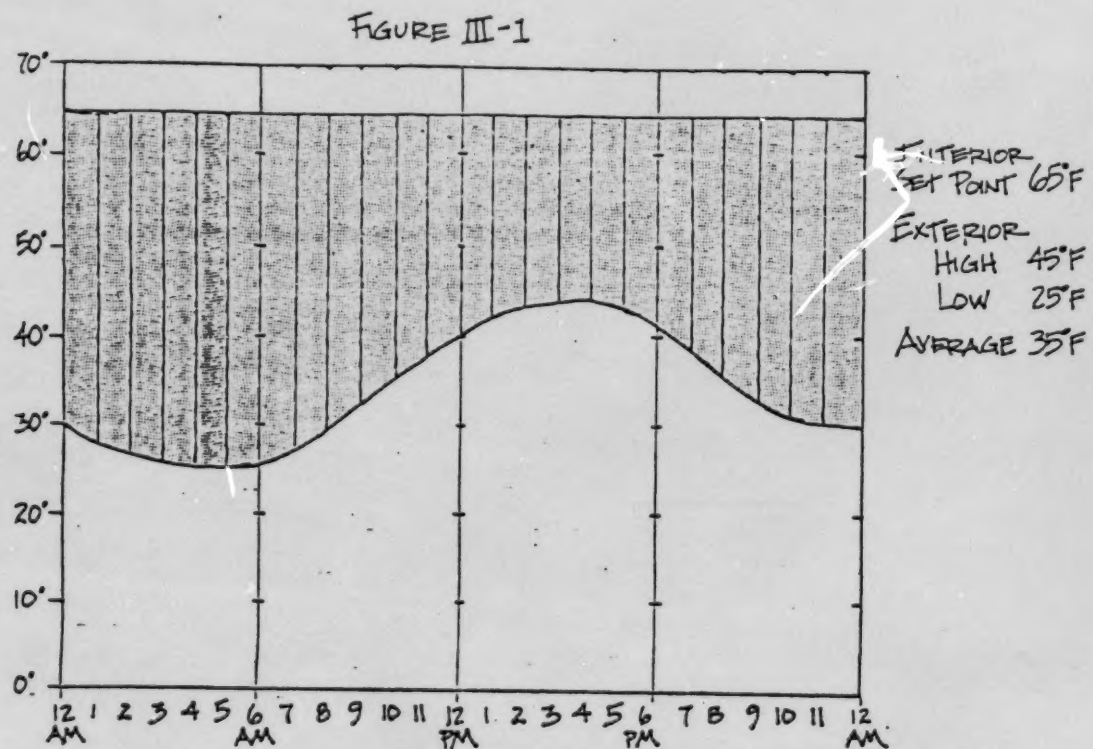
If we accept these restrictions, we can compute the heat loss graphically for each month and calculate our heat gains from the equations given earlier to determine our energy balance.

Heat Loss (L_T)

To calculate the heat loss, we must return to our earlier equation for heat loss and determine how much heat was lost per hour, for each degree of difference between the interior and exterior temperature. For example, if a house loses 50,000 BTU/hr when there is a Δt of 50° , we can say that the loss is 1000 BTU/hr for each degree difference. (This is the same as saying that the total UA for the structure is 1000 BTU/Degree Hour.) Thus, we know how much heat we lose per hour for each degree we are below the desired interior temperature. If we then need to calculate the heat loss for an hour when the outside temperature is 20°F below the interior, we simply multiply 20°F by 1000 BTU/Degree Hour.

To determine the heat loss for a day, we simply add up the separate losses for each hour by multiplying the sum of the Δt s for each hour in the 24-hour period by the heat loss factor (UA). $\Sigma \Delta t \cdot UA = L_T$

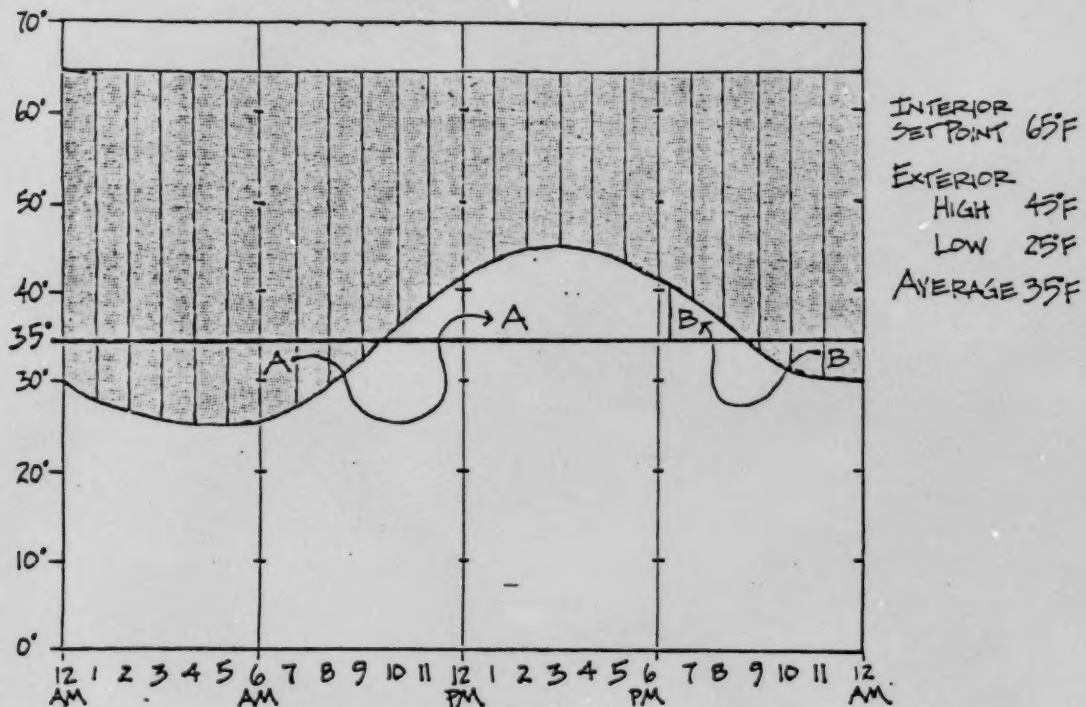
It is easy to show this by using a graph of the situation. Figure III-1 represents a typical day with a high of 45°F and a low of 25°F. A smooth curve has been drawn through those points to give the approximate temperature variation for the 24-hour period. A straight line has also been drawn across at the desired indoor temperature (set point). Note that the highest temperature typically occurs in mid-afternoon, not at noon, and the lowest temperature occurs in early morning.



Now, if we take the Δt between the set point and the curve for each of the 24 one-hour blocks, we can add them all and get our $\Sigma \Delta t$. There is an easier way, however. Since a

sine curve is symmetrical, when we average the high and low points on the curve, we get a mean value that can be represented as a straight line, which will give us the same results as the curve. This is because the sections below the line "fill in" for the sections above the line (see Figure III-2).

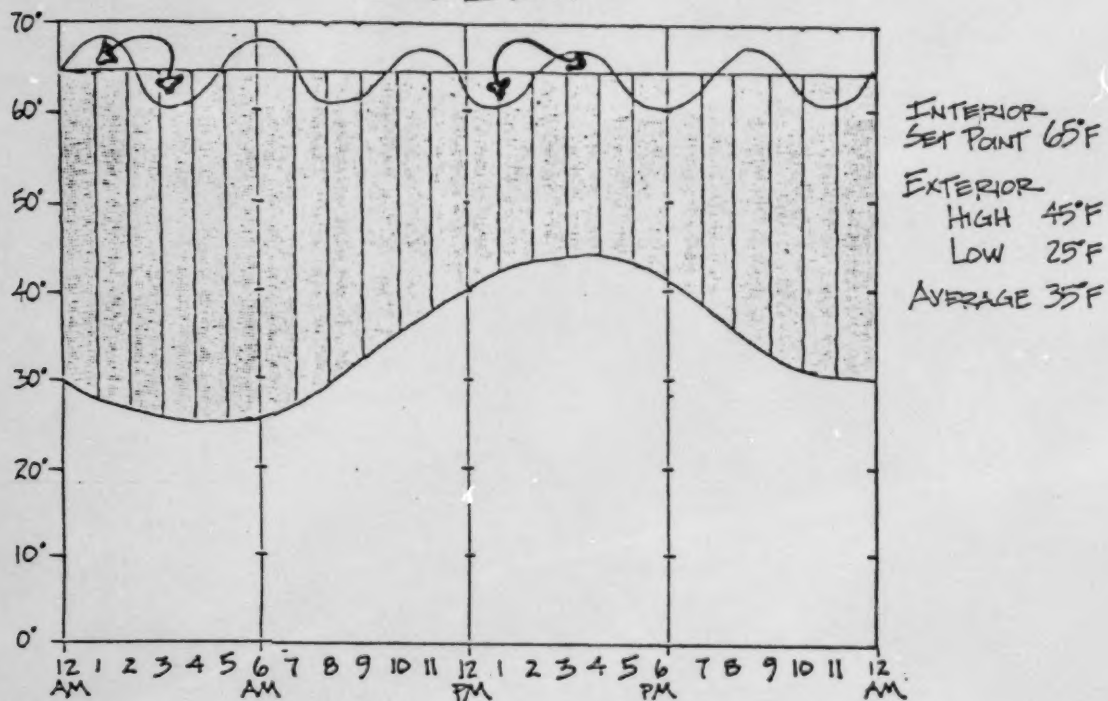
FIGURE III-2



In fact, in reality the furnace also does not provide a steady set point, but cycles ON and OFF around the set point. (This is called hysteresis.) Again, the areas below the average value compensate for those above, and can be approximated as a straight line. (See Figure III-2-A.) Now we can calculate the Δt since it is simply the number of hours (24) times the average Δt (30°F), or:

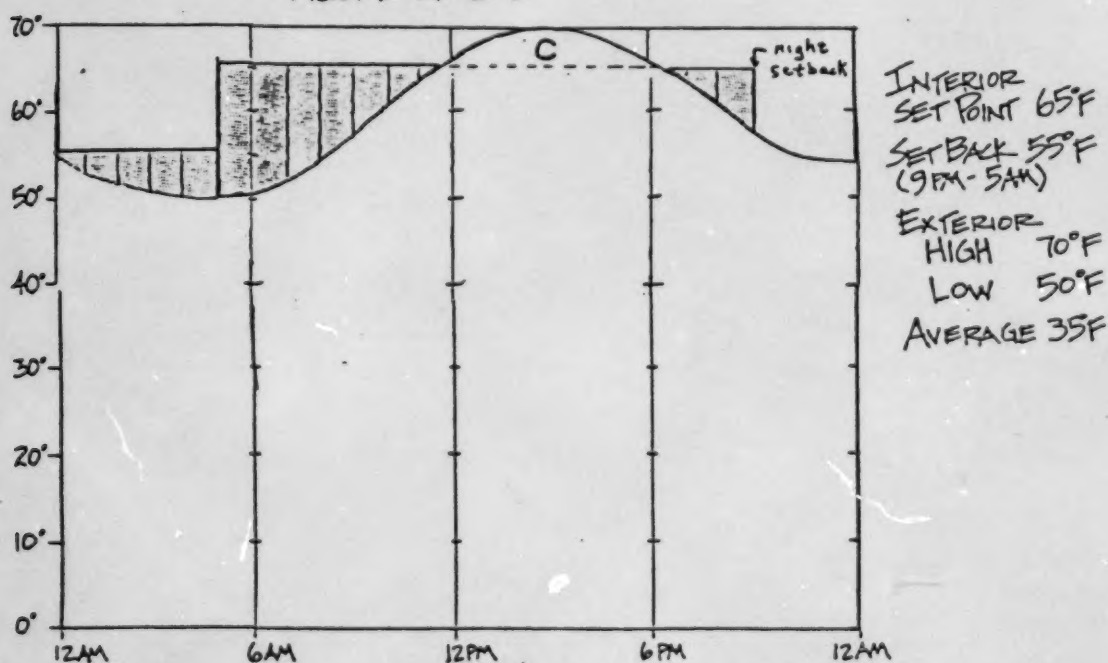
$$\Sigma \Delta t = 24 \text{ hours/day} \cdot 30^\circ \text{F} = 720 \text{ Degree Hours/day}$$

FIGURE III-2-A



One last caution: when the daily curve swings above the set point, it can not be counted because the heat available at that time can not be stored for later use in a standard home. Thus, you must subtract area 'C' from the total to get the actual heat load. (See Figure III-2-B.)

FIGURE III-2-B



If we now multiply this value times the heat loss factor (total UA), we get our total heat loss. For our previous example, this would mean:

$$L_T = \Sigma \Delta t \cdot UA$$

$$L_T = 720 \text{ Degree Hours} \cdot 1000 \text{ BTU/Degree Hour}$$

$$L_T = 720,000 \text{ BTU/day}$$

For the month we simply multiply by the number of days. For example, if this value was for January:

$$L_T = 720,000 \text{ BTU/day} \cdot 31 \text{ days}$$

$$L_T = 22,320,000 \text{ BTU/month, or}$$

$$L_T = 22.32 \text{ MBTU for January}$$

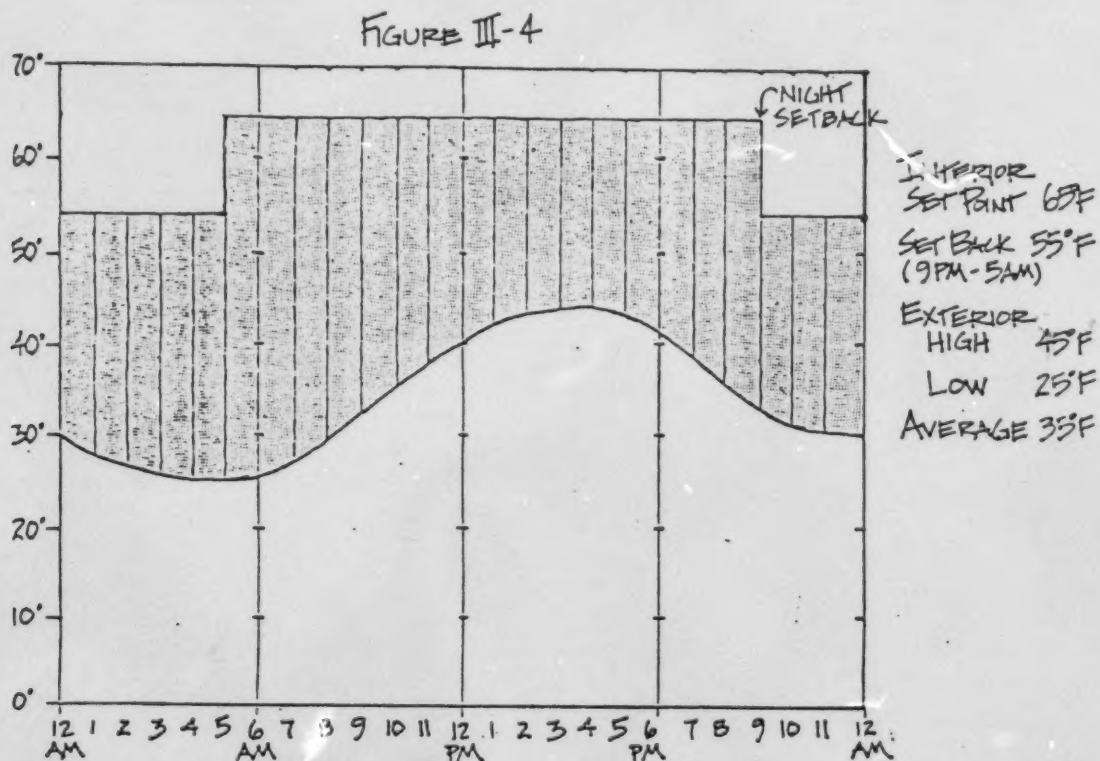
To carry out this calculation, we need to be able to get the average daily temperature values for each month. This is available from the U.S. Weather Service on a chart called "Meteorological Data for the Current Year." (See Figure III-3 for Seattle.)

FIGURE III-3

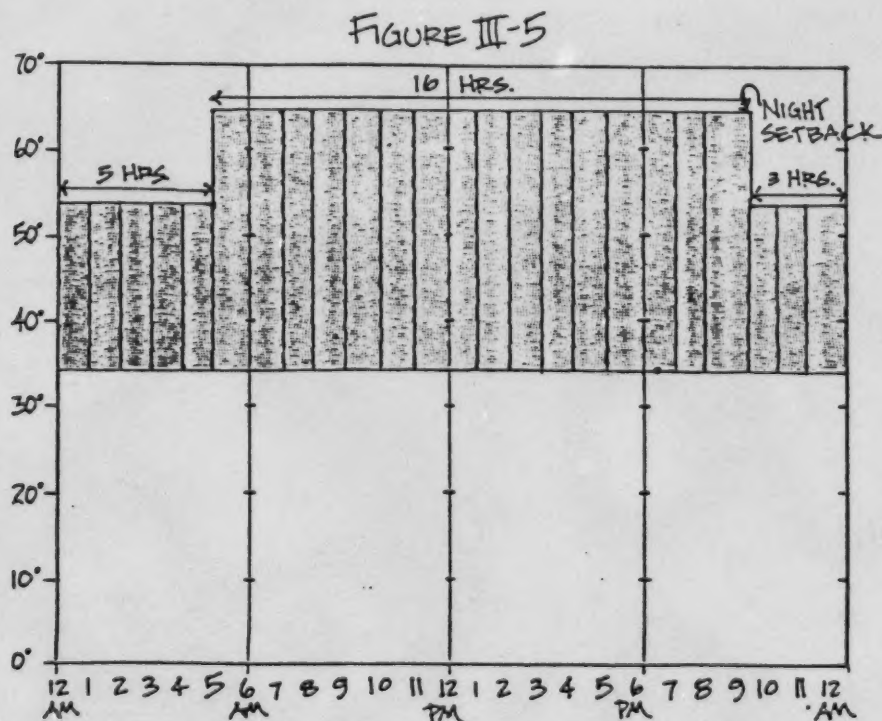
	J	F	M	A	M	J	
Daily Maximum	44.7	50.0	53.0	59.0	65.8	70.4	
Daily Minimum	34.7	36.9	38.0	41.8	47.1	52.1	
Average	39.7	43.5	45.5	50.4	56.5	61.3	
	J	A	S	O	N	D	ANNUAL
Daily Maximum	75.8	74.5	69.3	61.8	51.0	46.6	60.1
Daily Minimum	55.6	55.3	51.8	46.5	40.4	37.4	44.8
Average	65.7	64.9	60.6	54.2	45.7	42.0	52.5

This method also allows for a more detailed analysis of the daily use pattern, including conservation methods like set-backs. Let's look at the same example as before, with a night set-back to 55°F

from 9pm—5am (8 hours). Our graph now looks like Figure III-4;



averaged, it appears as in Figure III-5.



Now our calculation for $\Sigma \Delta t$ is:

$$\Sigma \Delta t = (8 \cdot 20^{\circ}\text{F}) + (16 \cdot 30^{\circ}\text{F})$$

$$\Sigma \Delta t = 160 + 480 = 640 \text{ Degree Hours,}$$

or about an 11% savings over no set-back.

One last complication. Since charts are usually given for days, rather than hours, and since months do not have equal numbers of days, we use the full one-day period as a standard for calculations. This means we need to convert our value for Degree Hours to Degree Days by dividing by 24 and then, to compensate, multiply the UA value by 24 to give a Daily Heat Loss Factor.

For example, if our Degree Hour value is 640 Degree Hours, then the Degree Day value is $640 \div 24$, or 26.6 Degree Days. This means that the average difference (Δt) between the inside and the outside for a whole day is 26.6°F . Likewise, if the hourly UA value is 1000 BTU/Degree Hour, then the Daily Heat Loss Factor is 24,000 BTU/Degree Day.

Note that both values now include a factor called Degree Days. The Degree Day (DD) figure tells us the average number of degrees we need to make up for each day to reach our desired interior temperature, and the ^{DAILY} Heat Loss Factor tells us how many BTUs it will take to do that for each degree needed.

4) The Confusing Case

In the previous section, we developed a term for calculating heat losses called the Degree Day (DD). Unfortunately, there are two types of Degree Days, the one just identified, and another that has been in use in the heating industry for many years. Conceptually they are similar, but they are not the same, and will give different results.

The Heating Industry's DD:

The 'Degree Day' method was meant to give a rough estimating tool to mechanical engineers, and provide them with an idea of annual performance of equipment and structures. This was relatively inconsequential, since the design of the system was always based on worse case peak design conditions, rather than the annual performance under average conditions.

The method uses a 70°F inside temperature and compensates for the internal gains and solar heat gains of the structure by reducing this base temperature to 65°F . This Degree Day base then became a standard for reporting heating load by the Weather Service over the last 25 years. It is computed as the integral of the curve of hourly temperature against the base temperature.

The assumptions implicit in this measure are:

- 1) that the temperature in the house is held constant at 70°F throughout the day and night;
- 2) that the amount of internal heat gain from lights and appliances, Q_{int} , is a fixed percentage of the total heat loss

for all houses. This implies a common low level of insulation; and 3) that the south-facing exposure is similar in each house, and the amount of heat gain due to this exposure, Q_{sol} , is similar in all houses and all climates during the heating season.

These assumptions are of course questionable, even given conventional construction. When higher levels of insulation and larger south-facing windows for enhanced solar gain are included, the balance point moves below 65°F, as the internal gains become a larger percentage of the heat requirement. Furthermore, we have no way of calculating the heat demand for any set point except 70°F.

Since the industry DD value includes a fixed value for $Q_{int} + Q_{sol}$, the resulting values are not heat losses, but heat loads for Q_{aux} . Thus, the industry's Design Heating Load is similar to our Hourly Heat Loss Factor, except that our value does not include a 'fudge factor' for gains. Those are calculated explicitly. Similarly, the industry's Design Heating Load (BTU/DD) is essentially the same as our Daily Heat Loss Factor except, again, it includes gains as well as losses.

The Solar DD:

To remedy this problem, our alternative method was developed. By returning to basic heat laws, the problems introduced by approximating gains and incorporating them into losses are avoided. The solar DD is based on the actual thermostat setting (with night set-back) versus daily temperature swings. The Δt s produced over the number of hours are expressed in Degree Hours, and reduced to Degree Days by dividing by 24 hours.

Q_{aux}:

This term represents the heating plant (furnace, wood stove, baseboard heater) and can be calculated from the amount of fuel used, its BTU value, and the furnace efficiency factor.

$$Q_{aux} = \text{amount of fuel} \cdot \text{BTU/unit fuel} \cdot \text{furnace efficiency factor}$$

$$Q_{aux} = 100 \text{ gallons oil/month} \cdot 140,000 \text{ BTU} \cdot .65$$

$$Q_{aux} = 9,100,000 \text{ BTU/month}$$

$$Q_{aux} = 12,600 \text{ BTU/hr}$$

(Always convert to BTU/hr.)

Note: furnace efficiency is a difficult factor to determine exactly, since it is dependent not only on the furnace rating, but on its operating condition as well. Dirty or poorly tuned furnaces may differ by 20% from rated values.

Q_{int}:

This second term represents heat gains from people and appliances. This value is extremely difficult to calculate accurately because of the wide variation in lifestyles and appliance use patterns. Several studies have been made of this factor (notably Balcomb, and HUD: Report #HUD-HAI-2). Three different approximations are commonly used. The first method uses a flat rate of 2000 BTU/hr or 48,000 BTU/day (based on the Balcomb study). This is a conservative estimate and should be considered a minimum for houses with a low occupancy rate.

For example, for a house occupied by several students who are at home only a few hours each day:

$$Q_{int} = 2000 \text{ BTU/hr}$$

If the same house is occupied by an elderly person who is home almost continually, and who is reasonably active, this is probably a low value.

A second approach uses the per person rate of 25,000 BTU/day (based on the HUD study). This is more realistic for houses with normal occupancy rates if there are two or more persons in residence.

For example, for a family of four:

$$Q_{int} = 25,000 \text{ BTU/day} \cdot 4 = 100,000 \text{ BTU/day}$$

$$Q_{int} = 4,167 \text{ BTU/hr}$$

A third method, useful for public buildings, uses a value of 400 BTU/hr per person (ASHRAE) during occupancy, and then adds 2000 BTU/hr for appliances when they are operating.

For example, for a classroom of 36 occupied from 8am—4pm:

$$Q_{int} = (36 \cdot 400) + 2000$$

$$Q_{int} = 14,400 + 2000 = 16,400 \text{ BTU/hr}$$

$$Q_{sol}:$$

The third factor can be calculated by taking the number of square feet of south-facing glazing and multiplying it by the available insolation per square foot (see Chart #21). Note that a) the chart is given by month since solar gain is only of value during months of heat demand; b) if the south windows use more than 10% of the wall area, they will overheat, so you should discount the gain by 50%, the portion that's usable; and c) the chart assumes no shading of windows. We will deal with the Sky Chart procedure for calculating shading in the section on solar water heaters.

For example, for a house with four 20 ft² windows on a 1000 ft² south side, in January—

(since 80 ft² is less than 10%, we will use full values)

$$Q_{sol} = 80 \text{ ft}^2 \cdot 617 \text{ BTU/ft}^2/\text{day}$$

$$Q_{sol} = 49,360 \text{ BTU/day}$$

$$Q_{sol} = 2055 \text{ BTU/hr}$$

Although we have given a method for determining each of the factors, we are usually trying to find a 'missing' factor. For example, we may wish to know how large a furnace (Q_{aux}) is needed to heat a certain building on the coldest day of the year. If:

$$Q_{aux} + Q_{int} + Q_{sol} = L_T, \text{ then}$$

$$Q_{aux} = L_T - (Q_{int} + Q_{sol})$$

/design heating load/

or, the furnace heat must equal the total losses from the building minus any gains from people, appliances, or solar to maintain a constant temperature. It also gives us a way of verifying the accuracy of our equations in predicting the behavior of the building, since the predicted performance can be matched to actual performance.

FILMS AND REFERENCE RESOURCES

ENERGY 130 - SOLAR ENERGY CONCEPTS

FILMS AND REFERENCE RESOURCES

ENERGY 130 - SOLAR ENERGY CONCEPTS

FILMS

"Solar Generation"

"Energy from the Sun"

REFERENCE SOURCES

Energy Strategy: The Road Not Taken?, by Amory B. Lovins, Chapter in
World Energy Strategies: Facts, Issues, and Options

TESTING EVALUATION

ENERGY 130 - SOLAR ENERGY CONCEPTS

FINAL EXAM

ENERGY 130 - SOLAR ENERGY CONCEPTS

Name _____

Circle the answer(s) which best fits the sentence or question. Fill in the blank where required with the most appropriate word(s).

1. The altitude of the sun in Seattle at noon on the winter solstice is about (24 degrees, 10 degrees, 18 degrees, 0 degrees, 90 degrees).
2. Collector tilt is most like: (solstice, azimuth, roof pitch, collector orientation, south).
3. Define BTU (British Thermal Unit):
4. Collector orientation is most like (tilt, altitude, azimuth, solstice, roof pitch).
5. Which of the following is NOT used as a heat transport fluid in solar heating systems (air, water, antifreeze, milk, H_2O).
6. Heat capacity of a substance is determined by multiplying its specific heat times its _____.
7. The major problem with water in a solar collector is: high cost, shortage, freezing, weight, color.
8. Air is (more or less) dense than water.
9. Which of the following is NOT a part of a solar collector? (glazing, absorber, transport fluid, frame, insulation, flashing, door).
10. Which of the following are basic components of a solar heating system? (collector, transport, pump, storage, drywall, lighting, controls)
11. A device that is used to transfer heat from one fluid to another is called a: (panel, heat exchanger, shovel, storage, header).
12. Double glazing (increases or decreases) the amount of energy reaching the absorber of a solar collector.

13. Absorbance, transmittance, and emittance are characteristics of a:
(heat pump, storage, insulation, selective surface, hot tub).
14. The total amount of solar radiation striking a surface exposed to the sky is called: (moonlight, insulation, diffuse, insolation).
15. The ratio of heat energy (BTU) extracted from a collector to the quantity of solar energy (BTU) striking the glazing, expressed in percent is called: (outlet temperature, flow rate, collector efficiency, conduction).
16. Which substance has a higher heat capacity? (air, cloth, water, glass, rock)
17. Tube, trickle, and sandwich type absorbers are used with (air or liquid) transport fluids.
18. What is the best (greatest solar heat available) direction to orient a solar collector?_____.
19. A well designed collector should be able to collect (25, 300, 1000, 2200) BTU's per square foot on a sunny winter day.
20. Which of the following are necessary to estimate the collector size? (collector output, heat capacity of rock, degree days, what time it is, heat loss of house).
21. Storage of solar heat is necessary because:
22. Solar heat is commonly stored in which 3 of the following? (air, water, glass, rock, phase change salts, milk).
23. One cubic foot of rock will store (more or less) heat than one cubic foot of water over the same temperature range.
24. Eutectic salts store heat energy as they (melt or freeze) and release it when they (melt or freeze).

25. What determines the maximum temperature of your storage?
26. What determines the minimum temperature of your storage?
27. Equinox occurs around the 21st of (April, June, March, October, September, December).
28. Define the R-value of a material.
29. Name three modes of heat transfer "flow".
_____, _____, and _____.
30. If we accumulated 10 degree days yesterday, what was the average temperature for the 24-hour period? _____.
31. What is the greenhouse effect?
32. Seattle has about _____ heating degree days annually.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

1. Students will become aware of the realities and potential of renewable energy sources in the Northwest.
2. Students will acquire basic information and techniques for utilizing small scale systems in construction.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

1. Lecture presentation of material.
2. Discussion activities encouraging class participation.
3. A term project will be required.
4. Up to two guest lecturers
5. Audio-visual materials used where applicable.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

A mid-term and final examination will be given.

Completion of term project.

Design an integrated energy system for a residence.

Use two or more renewable energy sources and show how they interact to provide the required energy load.

The residence should be your own, real or planned.

Provide at least two schematic drawings showing the layout and plan of the building system.

Provide a written summary of the systems, including how much energy you expect them to provide on a yearly and seasonal basis.

***GRADING:**

Course Standards

Attendance	10%
mid-term exam	20%
Final exam	35%
term project	35%
	<u>100%</u>

Grading Schedule

90-100%	A
80-89%	B
70-79%	C
60-69%	D
59% or below	E

*DETAILED COURSE OUTLINE:

- I. Energy Conservation (Jan. 3, 8, 10, 15)
 - A. Energy alternatives and the future.
 - B. How to cut energy consumption.
 1. Heat loss/gain analysis
 2. Methods of heat loss control
- II. Energy from the sun (Jan. 17, 22, 24)
 - A. The nature of sunshine and its collection
 1. Solar availability
 2. Solar heating system fundamentals
 - B. Solar hardware and architecture.
- III. Energy from wind (Jan. 29, 31, Feb. 5)
 - A. Finding how much is available
 - B. Wind energy systems
- IV. MID-TERM EXAMINATION (FEB. 7)
- V. Energy from water (Feb. 12, 14, 19)
 - A. Determining how much is available.
 - B. Systems that extract hydro energy.
- VI. Energy from Biofuels (Feb. 21, 26, 28)
 - A. Wood and wood stoves
 - B. Methane generation
 - C. Alcohol production
- VII. Integrated systems (March 4, 11)
- VIII. Project review (March 13)
- IX. FINAL EXAMINATION (MARCH 18)

TEXT: "ENERGY PRIMER:", R. merrill & T. Gage editors, 1978

RESOURCE TEXTS: "THE RAIN BOOK"
"SOFT TECH"

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

- | <u>Date</u> | <u>Procedure</u> | <u>By (signature):</u> |
|-------------|---|------------------------|
| *1. _____ | Course proposal form submitted to the office of the associate dean of instruction | _____ |
| 2. _____ | Page one completed. | |
| 3. _____ | Division recommends approval ()
Division recommends disapproval () | _____
(DR) |
| 4. _____ | Reviewed by director of learning center | _____
(DLR) |
| 5. _____ | Reviewed by Faculty-Administration Council. | _____ |
| 6. _____ | Dean of instruction approves ()
Dean of instruction disapproves () | _____
(DI) |
| 7. _____ | Course proposal form filed in temporary location. | |
| 8. _____ | Pages two and three completed (prior to the end of the quarter in which taught). | |
| 9. _____ | Page four completed. | |
| 10. _____ | Course proposal form filed in permanent location. | |

STUDENT OBJECTIVES AND CHARACTERISTICS

ENERGY 140 - RENEWABLE ENERGY SYSTEMS

STUDENT OBJECTIVES AND CHARACTERISTICS

ENERGY 140 - RENEWABLE ENERGY SYSTEMS

1. Students learned about the course through the college schedule, friend or relative, brochure, employer and other (prioritized)
2. Purpose for enrolling (in order of largest percentage)

For personal enrichment or to explore educational opportunities - 37%
To augment existing job skills - 29%
To prepare for a job in a new field - 26%
To complete only two years of education which might qualify me for an Associate of Technical Arts degree - 8%
3. Student credit hour loads were as follows: (in order of largest percentage)

6 - 9 credits - 42%
Less than 6 credits - 37%
10 - 14 credits - 17%
More than 18 credits - 4%
4. 65% of the students were employed an average of 40 hours or more per week.
5. 88% of the students planned on continuing in the program.
6. The average age of students enrolled in this course was between 26 and 35 years of age.

(see attached for additional comments)

RENEWABLE ENERGY SYSTEMS - Enrgy 140

IF EMPLOYED, JOB TITLE/POSITION AND HOW LONG IN INDUSTRY

Estimator, 3 years
Field glazer/manager, 3 years directly, 5 years indirectly
Engineering Aid, 1 year
Autokey clerk, 1 year
Painter, 8-9 mos. at Boeing, painting for 11-12 years
Owner of Oil Burner Service, 20 years
Manager, 3 years
Designer, 6 years
Retired
EFNEP Aide, 9½ years
Carpenter, 4 years
Mechanic, 2 years
Pharmacist, 33 years
General Contractor, 16 years
Energy Conservation Specialist Trainee, 1+ mo.
Salesman, 2 years
Researcher
Industrial Engineer, new job

WHAT DO YOU HOPE TO LEARN FROM THIS COURSE?

More Inf. about our dwindling energy resources
How to build a solar (passive) home, and to prepare me as a solar lobbyist
Whatever is taught and then some
I'd like to learn about working with sun, wind, wood, plants, weather and how they
relate to new construction and existing structure, in getting most efficiency.
To augment existing job skills in terms of new energy saving techniques in the
field of construction.
Basic plays on renewable energy systems
Whether I'm interested in continuing in this field and learn subject matter
The spectrum of renewable enrgies available.
Insights in energy related problems
Resource conservation and more efficient uses.
Methods of soft energy use applicable to the individual family.
Interested in building various types of energy-production systems. I know very little
about soft energy systems and would like to learn the basics.
Knowledge
A new skill that will help me and others.
Costs of different types of energy, how they can be applied in the Northwest
As much as possible on alt. energy systems
All about energy sources (that PUD doesn't use)
To augment existing job skills.
Enough to help me find a new high paying job.
Energy management
More than I know now.

WHAT ARE YOUR REASONS FOR TAKING THIS COURSE?

For personal enrichment or to explore education opportunities
Completion of degree.

To prepare for a job in a new field

for personal enrichment or to explore education opportunities

To augment existing job skills.

Be prepared for the future and gain skills for a new career

I enjoy energy and like learning/working with it. I want to get an ATA Degree
in the Energy Management course and possibly go on to a 4 year institution.

Furthering education in energy

A new skill that will help me and others

Personal enrichment, ATA

We are planning to build a home. Want to investigate alternate energy possibilities
also interested in the possibility of devoting more time to this field in terms
of investment/employment.

To provide sufficient know how to be able to design my own heating system.

Credit toward an ATA degree and toward future employment.

For personal enrichment or to explore education opportunities

To fulfill the requirements necessary to complete the energy management course

To learn whether I'm interested in continuing in this field and learn subject matter

A changing world

Desire to educate myself in new alternative energy sources for my industry

I feel that this course will help prepare me for surviving in the future to come

Enlightenment

How to become energy self-sufficient

Continued education, broadening of my horizon.

TEACHING METHODOLOGY

ENERGY 140 - RENEWABLE ENERGY SYSTEMS

ENERGY 140
Renewable Energy Systems
Class I

Introduction - Myself - why I'm teaching this course
class intros--

Appropriate Technology. Life style-

Course outline and text.

Project-

Grading - attendance 10%
Midterm 20%
Final 35%
Project 35%

Access-Whole Earth catalogues, Mother Earth News - Rain, Soft tech, Greenpeace
Chronicle.
Library - solar books-
Environmental Faire 6-7-8 April
NW Alternative Energy Fair 5-6-7 May, Gray's Harbor
Solar 79 10-11-12 August
WeWaSEA, PNWSEA, Ecotope

Break

E.C. will change our lives

What is Energy?-- fund. unit, force (gravity, electromag, weak interac., strong
inter.
work - force X distance
power - force X velocity
energy = power X time

Forms of Energy--Heat and Chemical BTU
gravity - 9.8 ft/sec/sec
mechanical - hp/hr or ftlb or joule
electrical 0 Kwh
tables of coversion

Laws of Thermodynamics - 1st constant amount but changeable
2nd constant degradation to heat.

Energy cannot be recycled - comes by only once, cannot "conserve" (save) but
only slow rate of wate prod.

Energy Conversion Table III

Efficiency - First Law Efficiency = $\frac{\text{Energy at end use}}{\text{Total actually used}}$
consider entire system.
Second Law Efficiency - $\frac{\text{minimum amt required}}{\text{Total actually used}}$ $\frac{\text{Theory}}{\text{actual}}$
Economic - life cycle cost or payback
Social - convenience

Renewable and Non Renewable Energy Resources
use rate - supply

Energy use in the Northwest

Class II

1. Roll call
2. Reading assignment next week. pp30-82
3. President's energy message
4. Energy Conservation. 30-50% savings in bldg. Heat.
 - Heat - motion of molecules - flows warm to cold
 - BTU - quan. of heat to raise 1 lb H₂O 1° F
 - BTU per hr. rate of heat flow.
 - Heat flow - conduction - direct transfer by molecular contact, requires a material
 - convection - causes fluids to move, natural forced.
 - Radiation - electromagnetic waves light, sun through space
 - Heat flow out of building = heat loss
 - heat flow into a building = heat gain
 - Heat flow out primarily by conduction and convection
 - conductance of a material - # BTU/hr /ft²/1° F ΔT.
 - resistance-opposite to conductance - measure of insulating ability, R-value
 - resistance of a building section - Wall--table 2
 - Floor--table 3
 - Ceiling--table 4

$$\text{eq. 1} \quad H_{tr} = \frac{\text{Area} \times \Delta T}{R_t}$$

$$\text{eq. 2} \quad H_{tr} = U \times A \times \Delta T$$

calculate for all exterior surfaces (building sec. type) and

Infiltration heat loss - crack length method ASHRAE
air change estimation - 1, 2, 3

$$H_{in} = C \times L \times Q \times \Delta T = C \times \text{vol. to be heated} \times \text{air change/hr} \times \Delta T$$

C=heat capacity of air (0.018 BTU/ft³/1°F

L=crack length

$Q = \text{ft}^3 \text{ air per foot of crack length per hour}$

$$H_{in} = C \times \text{house volume} \times \text{estimated air changes/hr} \times \Delta T$$

Total worst case (design heat load) = Htr for total building + H_{in}

heating system is designed to supply this load.

expand on heating system components. Clothes, fireplace, small electric heaters, etc.

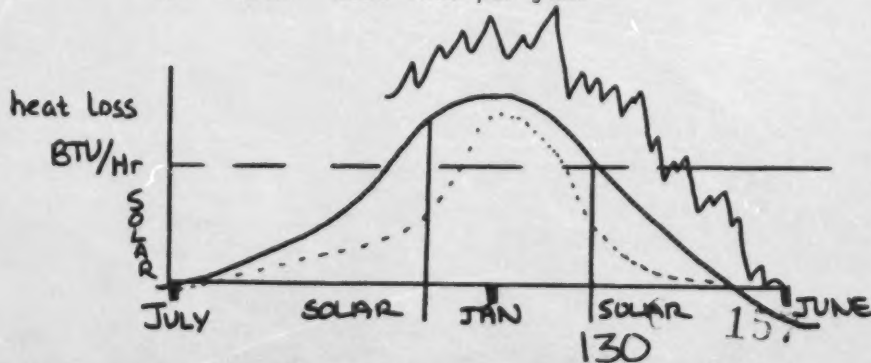
Seasonal Heat loss Tavle VI

$$H_{tr} = U_s \times A_s \times \text{degree hours}$$

(00 x 24)

$$5000 \times 24 = 120,000$$

$$H_{tr} + H_{in} = \text{heat loss per year}$$



Class II con't

Assignment - calculate design (worst case) and seasonal Heat loss for your house
Make a Tavle VI and Tavle Vii estimated

CLASS III

1. Roll call - all enrolled?
2. Home work conservation assignments - question
3. Basics of solar utilization - from hand out
4. Measuring sunshine
BTU
BTU/☐
BTU/☐/hr
BTU/☐/day
5. Greenhouse effect.

BREAK

6. Solar collection Transport next week - storage
DHW systems Thermosiphon
Pumped
air-water heat exchange
Space heating water-- active
air--

concentration collectors--temps above boiling, cooking, solar furnace, e-
vacuated tube

CLASS IV
WIND

roll call - mid-term next week

June 13 WeWaSEA - Wind - 7 pm WING.

- Wind machines - historical sailboats
- mills - 10th century Persia
- pumps - Midwest since 1860's
- generators - 1900's
- airplanes - gliders, prop driven
- present - 6 major manufacturers, Wincharger on N-Lake, 50w-6000w
- future - more technology--
- vortex towers
- wind generation - Utility scale - individual scale

Fig. 1 Wind system schematic

Economics - lowest cost per Kw/hr produced.
more intermittant than sun - sometimes too strong.

Cube Law - power available³ = windspeed

Fig. 2 Theoretical Power density - $P = (K \times A \times V^3) \times (.5926)$ Betz rule
 Betz Rule - theoretical limit of recovery is 59.26% x prop efficiency x
 generator efficiency = system 33.34%
 A disc area amt. of wind intercepted prop diameter

Table 2 - prop diameter - wind velocity power relationship

Environmental assessment--
 site dependent - WeWa - 8-12 mph ave w.v.
 laminar flow principles ~~Wawa~~ faster = more turb.
 prevailing direction.
 need to know - average yearly windspeed and windplant output
 anemometer - 6.95 - 90.00 surplus? at ht. and loc. of mast
 storage size: longest period of no wind and shortest period of some wind
 minimum required - 10 mph ave. on 2-3 days a week.
 6 mph lowest for any practical use.
 prevalent winds and 5-13 mph more frequent need larger diameter
 energy winds 23-23 mph less frequent 3/4 of power

Tower design - not roof mounted - load of 140 mph min.
30-40 ft. above ground
15-20 feet above obstacles within 500' radius. hill, ridge, cliff, geach.
wind blows parallel to ground--

Load - first determine how much electricity you need--critical convenience space heating
sizing 1. determine Kshr/mo output intermittant
2. determine capacity of batteries in Kwhr Watthr = amp/hr x volts
3. days of storage capacity = 2.

DC - AC requires inverter

Generator or alternator - low prop. speed 300-4-- rpm - requires low sp gen.

Wind con't

Blades and Hub - system efficiency limiting factor

blades with airfoil section to maximize lift (minimize drag)

high tip speed ration $\frac{\text{prop. tip speed (U)}}{\text{(wind velocity (v))}}$

propeller type has higher tip speed than multiblade

propeller type lightweight

propeller type direct drive generator

Precise balance very important - prevent vibration

all blades must be identical in lift as well as weight dist.

Tracking - blades follow each other in same plane

2 or 3 props usually economic decision.

2 - less drag = higher aerodynamic efficienct

3 - greater starting torque - better in lower winds, smoother in direction shifts

Figure 8 - text - and p. 135 Wind Mach. Taxonomy.

Feathering - cuts in above top efficiency speed to avoid damage.

air brakes - Fig 9

Vane control

variable pitch - stable output in varying wind speeds

Fig. 10 - Electro -

Fig. 11 - Quirk's -

200 rpm normal speed - 4-8 x wind velocity

Direct drive - max. gen output = max. prop output

p. 136 site profile

p. 138 WE storage

CLASS V WATER POWER

1. Hand out mid-terms and discuss
2. Power from Falling water-
Before steam engines, H₂O was most widely used power.
Handling and control of water one of oldest technologies--Romans, Mesopotamin, Incas, Europe
High efficiency of conversion possible due to simple machinery involved.
80-90%
Large scale potential mostly utilized over 90% in Washington and PNWest
Small scale e.g. individuals and small communities mostly untapped
Great applications potential in Mountainous Wet N.W.
3. Hydrologic cycle-
4. Waterwheels - large diameter, slow rpm, velocity and weight of water produce mechanical power - especially grinding and pumping needs gearing to produce electrical power.
Water Turbines - small diameter, high rpm - water pressure driven good for household level electricity when coupled with generator
5. Environmental considerations impact of dams.
6. Water rights
7. Measuring stream flow - all streams vary in flow.
Need: normal (average) flow and minimum flow.
cubic feet per second
also--cross section of stream and velocity feet per sec.
A. Bucket method - small streams known vol. of bucket x how fast it fills

B. Weir method - medium streams - controlled chanel
known depth and width - use table

C. Float method - X.C. area of stream + timed float
not as accurate, but simple
 $Q = A \times V$
8. Measuring Head. determines waterwheel or turbine choice.
Vertical distance water falls from any point A to point B
Head produces water pressure. Measured in pounds/in² (psi)
an elevation of head will produce same pressure regardless of volume of quantity of H₂O

9. Calculating Pwer - $THP = \frac{Q \times H}{8.8}$ Theoretical Horsepower
Head losses due to friction in pipe and available head
Efficiency of devices multiplied together
 $NHP = \frac{Q \times H \times E}{8.8}$
10. Dams - Divert H₂O into pipe-
Get civil engineering advice-

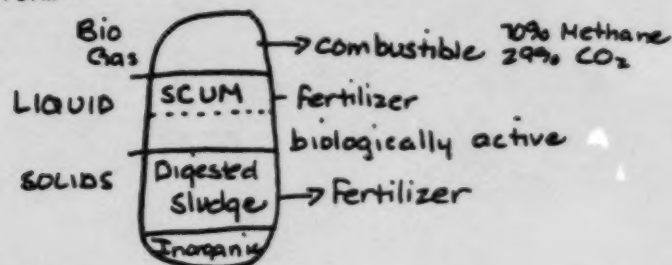
Water Power con't

11. Channels, Sluices and Pipes
 - means of transporting water from stream to wheel/turbine
 - low tech. waterwheels prob. use open channel or sluice
 - turbines require piping
 - canal - low velocity (level) ditch
 - sluice - open box channel or elevated flume (aqueduct), must be supported by strong structure (62.5 lbs/ft)
 - Pipe flow - large diameter, low pressure (culvert)
 - small diameter, high pressure (hose)
 - correct size important
 - distance of run decreases head due to friction loss in pipe
- 12.* Choosing a Turbine/waterwheel-
 - Factors to consider:
 1. flow rates, min, max in pipe
 2. available head
 3. site sketch with locations
 4. soil condition: erosion, channel, site, what to protect
 5. Pipe length
 6. Water condition
 7. Tailwater elevation
 8. air temp
 9. Type of power to be generated (mech., elec., etc.)
 10. cost/labor
 11. materials
 12. Maintenance
13. Wheels - undershot, breast, overshot
14. Turbines - used for producing electricity
 - 2 types: Impulse - use intomentum of a jet of water. Michell, Banki, Pelton.
 - Vertical mounted.
 - Reaction - Horizontal, Housing filled with water. Large scale type.
 - Michell (Banki) Turbine - OSU 1949. Paper on p. 119
 - simple to construct 65-84% or TE 88% efficiency
 - Nozzel
 - Turbine
 - Could run in backyard on hose pressure!!
 - Pelton - needs high head (50+ feet) small volume
 - high speed 1000 rpm up to 93% efficiency
 - difficult to build at home
 - Feed pipe long so allow 1/3 head loss
 - Reaction type - manufacturer built
15. Power transmission -
 - AC 60 cycle requires 3600 rpm/2 pole or 1800 rpm/4 pole gen.
 - DC auto system technology available -
 - gearing available in used machinery
16. Local information - p. 119 and Idaho E. Alt.

BIOMASS

Organic decay - chart - aerobic-compost

Methane systems - anaerobic
device - digester closed container
layers form-



Digestion

1. Solubilization - complex sub dissolved by enzymes. Hydrolysis results in simple amino acids, sugars
2. Acidogenesis - bacterial - facultative anaerobes, Oxy/reduction into short chains
3. Methanogenesis - anaerobic "methane formers" bacteria, slow growth rates. Rate limiting sensitivity

Digesters monitored for 3 indicators:

- pH - healthy: 7-7.5 6-6.5 to start up to 2 weeks
- volatile acids - indicates balance between acid formers and methane prod. increase precedes decrease in gas prod., methane content and low pH
- methane gas content - healthy: 60-70% CH_4

Properties of organic matter.

Water Total solids $\left\{ \begin{array}{l} \text{volatile solids} \\ \text{fixed solids-inert} \end{array} \right.$

example 197

Biomass resource--

Urban - Sewage - excrement and industrial flame at west pt.
.9 ft^3 gas/person/day
Solid waste - undiscovered 5-6 lbs/day/person

Agricultural - crops and crop residues - coarse and fibrous - not too good
Manure

Plantations - like a woodlot. Liquid waste aquatics most developed

milkweed in Utah - for petroleum

Algae - 200 #/day in California at 60% 720 ft^3/CH_4

Water Hyacinths!! 800-1600 #/acre/day 3500-7000 $\text{ft}^3/\text{acre/day}$

Kelp - Oceanic 500 $\text{ft}^3/\text{acre/day}$ in 1000 acres mod.

Feasibility - centralized waste treatment best.
small scale questionable

SUPPLEMENTAL INSTRUCTIONAL MATERIALS

ENERGY 140 - RENEWABLE ENERGY SYSTEMS

COURSE OUTLINE

RENEWABLE ENERGY SYSTEMS - ENERGY 140 - PERRY LCVELACE

WINTER 1980 - TUESDAY AND THURSDAY 6 to 7:15 pm.

- I. ENERGY CONSERVATION (JAN. 3, 8, 10, 15)
 - A. Energy alternatives and the future.
 - B. How to cut energy consumption.
 - 1. Heat loss/gain analysis.
 - 2. Methods of heat loss control.
- II. ENERGY FROM THE SUN (JAN. 17, 22, 24)
 - A. The nature of sunshine and its collection.
 - 1. Solar availability.
 - 2. Solar heating system fundamentals.
 - B. Solar hardware and architecture.
- III. ENERGY FROM WIND (JAN. 29, 31, FEB. 5)
 - A. Finding how much is available.
 - B. Wind energy systems.
- IV. MID TERM EXAMINATION (FEB. 7)
- V. ENERGY FROM WATER (FEB. 12, 14, 19)
 - A. Determining how much is available.
 - B. Systems that extract hydro energy.
- VI. ENERGY FROM BIOFUELS (FEB. 21, 26, 28)
 - A. Wood and Wood stoves.
 - B. Methane generation.
 - C. Alcohol production.
- VII. INTEGRATED SYSTEMS (MARCH 4, 11)
- VIII. PROJECT REVIEW (MARCH 13)
- IX. FINAL EXAMINATION (MARCH 18)

TEXT: Energy Primer, R. Merrill & T. Gage eds., 1978.

Many other resource materials will be used.

PROJECT:

- * Design an integrated energy system for a residence.
- * Use two or more renewable energy sources and show how they interact to provide the required energy load.
- * The residence should be your own, real or planned.
- * Provide at least two schematic drawings showing the layout and plan of the building systems.
- * Provide a written summary of the systems, including how much energy you expect them to provide on a yearly and seasonal basis.
- * Due Date is ~~March 1~~. MARCH 13 OR BEFORE

TESTING EVALUATION

ENERGY 140 - RENEWABLE ENERGY SYSTEMS

ENERGY 140 RENEWABLE ENERGY SYSTEMS MIDTERM EXAM FEB. 1980

Circle the answer (s) which best fit the sentence or question.

Fill in the blank where required with the most appropriate word (s).

1. What are the two biggest electrical energy users in your home?
_____, _____. (besides people)
2. How much electrical energy does your house consume per month?
_____.
3. Name 5 (five) ways wind energy can be used. _____,
_____, _____, _____, _____.
4. What are the major components of a wind generator system?
_____, _____, _____, _____.
5. What is the "Cube Law"?
6. Wind power Density is measured in units of _____.
7. The "Betz Rule" says that only _____% of the energy in wind
can be extracted by a propeller.
- 8/ Theoretical Power Density of wind may be calculated by
 $P = (K \times A \times V^3 \times .5925)$, where $A =$ _____ and $V =$ _____.
9. What further computation (from #8 above) is needed to find out
how much power you can expect from your wind generator?
10. The range of average annual windspeed in the Puget Sound region
is between _____ mph and _____ mph.
11. Doubling the prop diameter increases its power _____ times.
12. A solar heating system consists of three major subsystems.
They are _____, _____, and _____.
13. Name four types of passive solar heating systems. _____,
_____, _____, _____.

14. A flat plate solar collector has several components. How many can you name? _____, _____, _____, _____, _____.
15. The transport fluid in a solar heating system is usually _____ or _____.
16. What is the "greenhouse effect"?
17. A design temperature for heating used in Seattle is _____.
18. Seattle has about _____ heating degree days annually.
19. If we accumulated 20 degree days yesterday, what was the average temperature for the 24 hour period? _____
20. Define ΔT (delta T) as used in heat loss calculations.
21. Define BTU (British Thermal Unit).
22. Define R-value of a material.
23. What is the relationship between R-value and U-value?
24. Infiltration can be expressed as (BTU, R-value, Celsius, U-value, air changes per hour).
25. A U-value of .05 is an R-value of (4, 1, 10, 20, 30).
26. An R-value of 4 is a U-value of (1, 4, .4, .25, 2.5).
27. Which ceiling loses LESS heat? (One with a U-value of .12 of, One with a U-value of 1.2).
28. As insulation, a material with an R-value of 11 is (better or worse) than one with an R-value of 6.
29. Which house is more energy efficient:
 - a. 3000 ft² with design heat loss of 60000 BTU/hr.
 - b. 2000 ft² " " " " " 50000 BTU/hr.

30. The U. S. A. with less than $1/6$ of the world's population uses what proportion of the world's energy supplies?
($1/16$, $1/8$, $1/4$, $1/3$, $1/2$).
31. If you failed to recycle _____ (how many?) aluminum cans, you would waste more energy than is used daily by a person in a developing nation.
32. The total energy use of the 800 million Chinese is equivalent to the energy used in Americans' _____.
(cars, airconditioners, houses, appliances)
33. One fast-food chain (MacDonalds?) uses 174 million pounds of paper per year, which is the yield from _____
square miles of forest.
34. _____% of the cars being ~~a~~ operated in this country at any one time carry only one driver.
35. Bicycles are _____ times more effecient than cars.
Walking is _____ times more effecient than cars.
Busses are _____ times more effecient than cars.
Trains are _____ times more effecient than cars.

FINAL EXAM - RENEWABLE ENERGY SYSTEMS - ENERGY 140 - March 80

Fill in the blank where required with the most appropriate word(s).

1. A U-value of .05 is an R-value of (a) 4, (b) 1, (c) 10, (d) 20,
2. An R-value of 4 is a U-value of (a) 1, (b) .4, (c) .25, (e) 2.5.
3. As insulation, a material with an R-value of 11 is (a) better, or (b) worse than one with an R-value of 6.
4. What is the "greenhouse effect"?
5. Heat flows in three ways. Name them: (1) _____, (2) _____, and (3) _____.
6. Define R-value of a material.
7. What is the relationship between R-value and U-value?
8. If we accumulated 25 degree days (heating) yesterday, what was the average temperature for the 24 hour period? _____.
9. Define ΔT (delta T) as used in heat loss calculations.
10. What is meant by "Renewable Energy Sources"?
11. What is the ~~most~~ simplest most effective way to cut fireplace heat losses?
12. An air tight wood stove may be as high as _____% efficient.
13. Heating efficiency of a typical fireplace (no heat exchanger) is about _____%.
14. A cord of wood contains about _____ BTU's.
15. What size is a cord of wood? _____ ft. by _____ ft. by _____ ft.
16. The flammable ingredient in bio-gas is _____.

2.

17. What are three uses of wind machines? _____,
_____.

18. What is the Cube Law?

19. The Betz Rule says that only _____% of the energy in wind
can be extracted by a propeller.

20. Theoretical Power Density of wind may be expressed as
 $P = (K \cdot A \cdot V^3) \cdot (.5926)$, where $A =$ _____
and $V =$ _____.

21. Doubling the prop diameter increases its power _____ times.

22. A design temperature used for heating in Seattle is _____.

23. Seattle has about _____ heating degree days annually.

24. Define BTU (British Thermal Unit).

25. How many BTU equal 1 kilowatt at end use? _____

26. How many BTU worth of oil or coal are needed to produce
1 kilowatt of electricity? _____

27. What are two devices used to harness small stream power?
_____, _____.

28. Stream flow is measured in _____ units.

29. What are two methods of measuring stream flow?
_____, _____.

30. Define "Head" as pertains to a stream.

31. Why is it that the further you carry water in a pipe, the greater
is the loss of head?

32. Name two types of water turbines. _____,
_____.

33. Water weighs _____ pounds per cubic foot.

34. What does "psi" stand for?

3.

35. The process by which green plants convert light energy into chemical energy is known as _____.
36. Artificial anaerobic decay is carried out in a device called a _____.
37. What is the difference between aerobic and anaerobic decay?
38. Fermentation followed by distillation is a method for producing the fuel _____.
39. Oil, coal, wood, alcohol, etc. are fuels from which useful energy is extracted by the process of _____ which consumes the gas _____ and releases the gas _____.
41. Name five fuels that don't produce carbon dioxide (CO_2) when used.

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY

150

*Course abbrev.

*Course number

Check ONE: ☒ **NEW COURSE PROPOSAL:** complete ALL items below.
☐ **SYLLABUS UPDATE:** complete only items marked with asterisk (*).
☐ **REVISION:** specify change _____

***COURSE TITLE:** (Practical Thermodynamics) FUNDAMENTALS OF HEAT TRANSFER

STUDENT CLASS HOURS: 55 lect. lect/ lab shop clin. other syst.
lab.

5 55 35 .333
Credits **Instructor** **Capacity (est.)** **FTEF fraction** **Fee** **HEGIS code**
contact hrs.

PREREQUISITE: ENRGY 100 and high school physics

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer ☒ occupational preparatory ☐ community service
☐ academic basic ☐ occupational supplementary
☐ academic general ☐ occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

Persons interested in the energy field as a career, and students enrolled in Energy Management or in Construction Technology programs.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution ☐ ☐ AAS electives ☐ ☐ AAS electives ☒ ☐
 (transfer only) yes no (transfer only) yes no (15 credit yes no
 block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ ☒
 yes no

CATALOG DESCRIPTION:

Heat and heat flow: principles, measurements, and applications in energy system design and operation. Topics include: heat and temperature, thermodynamic laws, thermal properties of materials, heat transfer, heat recovery and cogeneration, heat engines and power generation, refrigeration and heat pumps. Prerequisites: ENRGY 100 and high school physics

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

1. Students will become familiar with formal definitions and practical measurement of basic concepts concerning heat and heat flow, including: quantity of heat, temperature, heat capacity, specific heat, conductivity, power, efficiency, coefficient of performance.
2. Students will also become familiar with basic principles governing heat flow, and their implications for methods of energy conservation and delivery, and for the consequent proper design of conservation and delivery systems.
3. Students will, in particular, become familiar with the concepts and ideas underlying course ENRGY 210 (Energy Auditing/Calculations) and course CONST 170 (Introduction to Mechanical Systems), and -- in part -- conservation and solar design courses (ENRGY 110 and ENRGY 130).

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

Methods of instruction will include: lectures and in-class demonstrations (some of which will require measuring or testing apparatus), discussion, home study problems.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Examinations for evaluating student attainment of objectives will comprise a midterm and a final, with an occasional quiz, notebook and projects.

***GRADING:**

<u>Course Standards</u>		<u>Grading Schedule</u>	
Quizzes	25%	90-100%	A
Notebook/Projects	25%	80-89%	B
Mid-term	20%	70-79%	C
Finals exams	30%	60-69%	D
		59% or below	E

***DETAILED COURSE OUTLINE:**

Text: "Text" for this course will be instructor notes. These will usually include a week's advance of brief text, questions for discussion and followup, questions for exploration, and problems for computation.

For background and alternative treatments, consult your "favorite" high-school physics texts -- their sections on "heat" -- at least for the first part of the course. Consult your own experiences! Think of your own questions as well as those handed out!

1. Introduction:
Course scope and objectives. Introduction to heat, temperature, heat flow. Units of measurement. Measurement and scales of temperature. Heat capacity.
2. Physical properties; First Law.
Molecular picture. Ideal and other gases. Thermal expansion. Phase changes. First Law: conservation of energy. Implications.
3. Second Law
Statements. Implications, Carnot engines, Carnot efficiency.
4. Basic heat transfer: conduction.
Fourier and Newton laws. Everyday implications. Conductivity. Concept of R-value.
5. Basic heat transfer: convection MIDTERM (through item 4)
Convection in nature. Convective losses. Considerations of moisture and humidity.
6. Basic heat transfer: radiation.
Radiation, absorption, emission. Blackbody radiation, Stefan law. Earth's energy balance. Human comfort.
7. Heat exchangers and heat-moving devices.
Heat exchangers. Mechanical heat and cooling devices. Natural heating, cooling. Refrigeration and heat pumps.
8. Heat generators and heat convertors.
Combustion and furnaces. Heat engines for mechanical and electric power.
9. System design and energy conservation techniques.
Heat recovery, cogeneration, lower-temperature reservoirs with site booster-heat, etc.
10. Review
11. FINAL

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1. _____	Course proposal form submitted to the office of the associate dean of instruction	_____
2. _____	Page one completed.	
3. _____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4. _____	Reviewed by director of learning center	_____ (DLR)
5. _____	Reviewed by Faculty-Administration Council.	
6. _____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7. _____	Course proposal form filed in temporary location.	
8. _____	Pages two and three completed (prior to the end of the quarter in which taught).	
9. _____	Page four completed.	
10. _____	Course proposal form filed in permanent location.	

VJD:101979

STUDENT OBJECTIVES AND CHARACTERISTICS

ENERGY 150 - FUNDAMENTALS OF HEAT TRANSFER

STUDENT OBJECTIVES AND CHARACTERISTICS

ENERGY 150 - FUNDAMENTALS OF HEAT TRANSFER

1. Students learned about the course through the college schedule, friend or relative, other and brochure (Prioritized)
2. Purpose for enrolling (in order of largest percentage)

For personal enrichment or to explore educational opportunities - 31%
To prepare for a job in a new field - 26%
To complete only two years of education which might qualify me for an Associate of Technical Arts degree - 22%
To augment existing job skills - 13%
To complete courses with the intent of transferring earned credits to a four year institution - 4%
None of the above apply - 4%
3. Student credit hour loads were as follows: (in order of largest percentage)

6 to 9 credits - 69%
10 to 14 credits - 19%
Less than 6 credits - 12%
4. 81% of the students were employed an average of 40 hours or more per week.
5. 100% of the students planned on continuing in the program.
6. The average age of students enrolled in this course was between 26 and 35 years of age.

(see attached for additional comments)

IF EMPLOYED, JOB TITLE/POSITION AND HOW LONG IN INDUSTRY.

Letter carrier, 2 years
Management consultant
Architect, 5 years
Gift show coordinator, 2 years
Engineering Aid, 1 year
Carpenter, 4 years
Painter, 10 mos. at Boeing, 10 years painting autos.
Manager, 3 years
Energy Conservation Specialist Trainee, new job
Field glazer, 4 years
Resource evaluation, 4 days
Autokey clerk, 1 year
Salesman, 7 years
Energy Conservation Specialist Trainee, 2 months
Boilermaker/Mechanic, 10 years

WHAT DO YOU HOPE TO LEARN FROM THIS COURSE?

Lots
I hope to learn where and why heat moves. And apply that to design and construction of housing and equipment.
How to make heat flow calculations
Simple heat flow
Practical thermodynamics
Principals of heat loss and how to apply them at a basic level
How to prepare my home to be energy efficient and how to do and prepare an energy audit
More about energy and thermodynamics
Heat conversion, etc.
More than I know now
Some basic physics relating to the field of energy
Useful knowledge and potential use.
Ways to conserve energy and create renewable energy

WHAT ARE YOUR REASONS FOR TAKING THIS COURSE?

Only courses on energy conservation in area.
Personal gain
Would like to learn a new job skill.
For personal enrichment or to explore education opportunities.
To augment existing job skills
Comply with degree outline for energy management
I enjoy energy. I think it's fascinating the way it works and why. And I want to learn more about it so as to apply it in alternative energy systems.
Degree, knowledge and personal satisfaction
To develop skills for my job
To prepare for a job in a new field, for personal enrichment or to explore education opportunities.
To complete only two years of education which might qualify me for an Associate of Technical Arts degree.
Part of the requirements.
To prepare for a job in a new field.
To learn where and why heat moves.
To learn lots

TEACHING METHODOLOGY

ENERGY 150 - FUNDAMENTALS OF HEAT TRANSFER

Introduce self, go over outline. Get EMT program description to everyone. Who is in program? Everyone introduce selves, describe interest, expectations. Explain procedures with handouts - problems. Course is about heat, the way it works, and examples of how we can use knowledge about heat. But one direct experience is with temperature.

Follow questions on week 1 handout:

Why study heat? End use of energy
Where to start? Hot/cold in experience.

Consistent changes observed with heating/cooling?

Different samples of water freeze at same time, freezing matches up with level of mercury in tube, always the same.

Consistent concept: "level of hotness"

"Measure" temperature(s) with devices called thermometer.

What kinds:

Temp. scales.

Effects of temp. change - thermal expansion. Class experiences?

Heat: btu, kcal

Heat capacity. Units.

Heat flow: $Q = cpmst/ \times T$ Experiences?

Rate of cooling experiment in class. Ask for volunteers to check and record temp. of hot water cooling in various vessels - glass, styro cups, etc.

QUESTIONS FOR DISCUSSION OR ELABORATION OR EXPLORATION(signified by *).

1. What feature is common to the Kelvin and Rankine scales? to the Kelvin & Celsius scales?
2. Which temperature scale might originally have been defined as follows: 0° is the temperature on a very cold day, 100° is the temperature of someone with fever? What is all right and what is wrong with such a "definition"?
3. What could we mean by "negative temperature"? What could we mean by "doubled temperature"? What care is needed in using these terms?
4. How many times hotter is a liter of water at 20°C than at 10°C ? Does the previous question make any sense? How much hotter is a liter of water at 20°C than at 10°C ? Does the previous question make any sense?
- 5* How does pressure affect temperature at which phase changes occur? What is a phase diagram, what is a critical point, and what is a triple point?
- 6* What is an electrical resistance thermometer? How does it work and when is it used?
- 7* What is a thermocouple? How does it work and when is it used?
- 8* What kind of thermal sensors are available and how do they work? Describe as many different types of thermometers as you can.
- 9* What kind of thermostats are available, and how do they work?

PROBLEMS FOR COMPUTATION

1. A silver block is exactly 4 cm long at 25°C . How long is it at 60°C ?
2. Cross-country RR iron rails 60 feet long when nailed into place at 40°C will have gaps of how wide at -40°C ?
3. If cooling reduces the length of a 50 cm silver bar by 1 mm, how much is it cooled?
4. How many btu are needed to raise the temperature of 500 pounds (about 60 gal) of water from 60°F to 120°F in a domestic water tank?
5. How many kcal are needed to raise 2 kg of iron from 20°C to 90°C ?
6. How much heat is needed to raise 5 kg of ice from -20°C to water at 70°C ?
7. If steam at 100°C is added to an equal mass of ice at -200°C , what should result?

Physical properties: First Law

Each time, ask class for their experiences.

Physical properties:

Thermal expansion - recall: Review Week 1 problems

Phase changes - class experience - water, refrigerants,...

Pressure effects, to change temp. etc. of phase change, and expansions

Gases. Boyle's law. Guy Lussac's law.

Absolute Zero. Kelvin temp. Charles Law

Ideal gases. Other gases.

"Insider view of heat"

Why do we view heat as form of energy?

Needed if law of conservation of energy, already accepted for mechanical energy, is to hold true. For example:

Work	Kinetic energy	potential energy	K.E. (heat)	
Toss rock	topward	top of cliff	falls (	smashes heat

It is almost as if heat ought to be a form of K.E. for very small particles (after smashing). This "kinetic energy" of heat grew up with the "molecular theory" of matter.

Heat = "left-over" individual motions of ultimate particles (molecules)

Evidence for molecules? Class?

Oil slicks disappearing (monolayer)

Brownian motion.

Behavior of gases and chemical reactions:

Simple ratios by volume; consistent proportions by weight or volume.

Simple relationships between "before" and "after".

Suggest elements in atoms groups in consistent small groups, "molecules".

2-atom elemental gas molecules.

Avogadro.

Avogadro-hypothesis. $N = 6 \times 10^{23}$

Ideal gas law $PV/T = nR$ $R = \text{constant}$
 $n = \text{number of molecules}$

Second Law.

Heat always flows downhill (higher to lower temp.)

No process can occur which has net effect of changing heat to work.

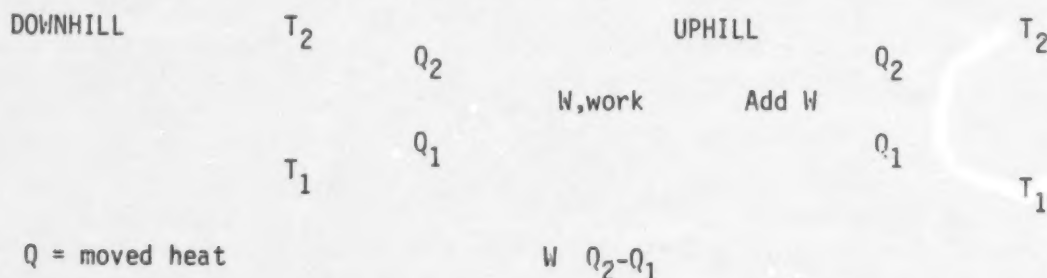
"Entropy" never decreases.

Entropy change = heat change x "unavailability" of heat supply.

$$\text{"unavailability"} = \frac{1}{\text{quality}} = \frac{1}{\text{absolute temp.}}$$

If heat is moved from temperature T_2 (higher temp.) to T_1 (lower temp.), the work which can be gained (by a heat engine) by moving Q_2 downhill and rejecting Q_1 at T_1 , is no more than the work needed (by a heat pump or refrigerator)

Statement in terms of efficiency, Carnot engines:



Carnot described a reversible process (either direction possible) wherein:

$$W = W_1 = Q_2 - Q_1$$

In this process, $W = Q_2 - Q_1$, and in terms of absolute temps, $T_2/T_1 = Q_2/Q_1$, or $Q_2/T_2 = Q_1/T_1$ - zero entropy change.

$$\text{The "efficiency" of the "heat engine" direction} = \frac{\text{work gained}}{\text{heat furnished}} = \frac{W}{Q_2} = \frac{Q_2 - Q_1}{Q_2} = \frac{T_2 - T_1}{T_2}$$

This process involves least possible work, therefore highest efficiency. Thus, Carnot's engine gives a maximum possible efficiency for a heat engine.

Actual efficiencies of practical devices are much lower. Ideas why?

Carnot's idea also limits "efficiencies" (COP's) for heat pumps. How? How do his theoretical COPs compare with actual?

QUESTIONS FOR DISCUSSION OR ELABORATION OR EXPLORATION (signified by *).

1. What happens when you keep open the door of your fridge in order to cool your kitchen?
2. The rate at which your house loses heat is determined by (choose one statement):
 - a. Just the outside temperature.
 - b. Just the inside temperature.
 - c. The ratio between the inside and outside absolute temperatures.
 - d. The difference between the inside and outside temperatures.
3. Why is filling the walls of a house with fibreglass or cellulose better for keeping heat in or out, even though air is a very poor conductor of heat?
- 4* How does a thermos flask keep a liquid hot or cold?
5. What are the modes of heat transfer? How do they differ? Give one example of each.
6. If your house loses 10,000 btu per hour when it is 65 F inside and 45 F outside, how much does it lose when it is 70 F inside and 30 F outside?
- 7* What sort of test would definitively establish the insulation value of fibreglass? Of brick?

PROBLEMS FOR COMPUTATION

1. If a chest holds 0.25 m^3 (about 9 ft^3) of air at atmospheric pressure (760 mm. mercury), and 0 C, what will be the pressure at 100 C ? Take air as ideal gas.
2. If in 1. the same air is maintained at 760 mm mercury pressure, what will be its volume at 100 C ? Take air as ideal gas.

E 150 Week 4

Heat transfer - conduction

$$Q = \text{const} \times T$$

Newton Law.

Conduction: $\text{const} = U \times \text{area}$

Units of U.

$$R = 1/U$$

R's can be added. Why? Let's view heat transfer as something which happens in response to temp. grad.

Fourier version: $Q = k \times \text{area} \times \frac{T}{x}$

temp. diff
thickness

temp. gradient

conductivity

Sample problems.

House-wall sections

Moisture analogy: vapor transfer = permeability x area x pressure gradient

E 150 Week 5

Review for mid-term (through week 4), sample mid-term

Convection: Back to $Q = UA \Delta T$

Only now U refers to convection transfer, usually written h rather than U , and dependent not on thickness of material but nature and relative motions of materials on each side of the boundary surface.

Explain "wind chill factor"

removal of heat in wind (convection) which would otherwise require much higher T to remove without wind.

Energy available from wind - Betz law - possibly of interest.

ENERGY 150

PROBLEMS 7 FEB 80

1. What potential energy, due to gravity and height is in 1 kg water 100 m above ground?
2. If sample in 1 falls, how fast will it hit ground?
3. If sample in 1 has all its energy of falling motion converted to heat, what will be ΔT , the temperature increase?
- 4., 5., 6. Same as 1., 2., 3. where sample is iron, not water.
7. Air travelling at 10 m/s is stopped by 1 m² blades, and all the energy in the air stream is converted to energy of rotary motion in the blades, and then to electricity. What power (rate of energy delivery) is generated?
8. If 1 HP (horsepower) $\approx$ 3/4 kW, how many hp are being furnished?
9. What happens if in 7., 8., 10 m/s is replaced by 5 m/s?
Discuss implications for fans and wind generators.

Radiation

Examples of radioactive heat transfer: sun, fires, heat cort - direct line

Complication: radiation transfers energy ("electromagnetic" energy), some of which is perceived as heat.

Electromagnetic spectrum.

Waves. Energy of wave packet (quantum), speed of light, Ir, visible, UV "light or radiation.

Distribution of energy among different wave lengths - depending on temp. of emitting surface. $Q = OA T^4$ abs. temp.
Stefran Law.

Emissivity. Reflectivity. absolutivity. Black body.

Kirchoff law: Why Kirchoff's law doesn't explain everything.

Reradiation at lower frequencies (energies) selective surfaces.

How radiation supplies energy to and removes it from earth.

Opportunity to engineer systems based on radiant heating to save energy. Complexity of $Q = UA T$ for radiation case. 1 example problem.

Practical Thermodynamics -- Week 6

PROBLEMS

Take air to weigh 29 g / mole, and a mole to occupy 22.4 liters at 0 C and atmospheric pressure.

1. A 2-liter jar of air at 300 K is heated to 400 K, open. Jar is then sealed and cooled back to 300 K. How many grams of air are now in the jar and what is the pressure of air in the jar?

*2. Use the equation $pV = nRT$, where R is nearly 8.3 joules/mole °C, to determine the average kinetic energy of a single molecule, assuming that the sum of the kinetic energy of molecules in a gas sample of 1 liter (at 0C and atmospheric pressure) accounts for the number nRT . (Take Avogadro's number as 6×10^{23} .)

OUTLINE -- FIRST AND SECOND LAWS

FIRST LAW

Work energy = force x distance moved against force.

Kinetic (motion) energy = $\frac{1}{2}$ mass x (velocity)².

Units: kilogram, second, meter. Newton = kilogram-meter/sec².

Joule = Newton-meter. Acceleration of gravity = 9.8 m/s².

lb-force = force of gravity on mass of 1 lb.

ft-lb = unit of work energy.

Mechanical equivalent of heat: 4.19 kJ = 1 kcal, 1 btu = 778 ft-lb.

Energy is conserved: it just has different forms.

SECOND LAW

Efficiency of a heat engine = work output/ heat input, = heat lost/ heat input
= $Q_2 - Q_1 / Q_2$.

For an ideal gas, $=(T_2 - T_1) / T_2$. (Q_2, T_2 refer to higher temperature.)

Carnot's reversible heat-engine/refrigerator.

Heat always flows downhill. No process can occur which has net effect of changing heat to work. Entropy never decreases.

Entropy change = heat change/ (absolute temp. of heat supply)
= heat change x "unavailability" of heat supply
= heat change/ "quality of heat supply".

Effects of pressure

Pressure increase can sometimes replace temperature increase.

Critical temperature, critical pressure.

Effects on gases: Boyle's Law.

Thermometry of gasses

Gay-Lussac's law of gas thermal expansion. Ideal gases.

Zero-volume temperature. Absolute temperature scales.

Charles' Law.

Kinetic theory of heat.

Molecular theory of matter.

Films.

Gay-Lussac's law of equal volumes.

Law of simple multiple proportions.

Atomic theory.

Molecular theory.

Gas molecules.

Avogadro's hypothesis.

Mole volume, gram molecular weight.

Ideal gases. Ideal gas law.

QUESTIONS FOR DISCUSSION: Identify each of the above outlined concepts as precisely as you can.

Week 6 -- NOTES: recap.

QUIZ Tu 22 Jan. 1. Does a pressure cooker raise or lower boiling point?

2. How and why is the resulting effect desirable for cooking?

3. If a 2-meter-long iron bar is heated from 20 C to 45 C, how much longer does it get?

4. How many kcal are released when 5 kg of water at 20 C are cooled & frozen at 0 C ?

Answers: 1. Raises. 2. Heat energy goes into increasing water temperature rather than phase change to steam. Higher temp. permits higher rate of heat transfer into cooking objects, permitting faster cooking. (Also, sealed container retains food nutrients and tastes.) 3. Increase = expansion coefficient x temp. difference x length = $11 \text{ millionths} \times 25 \times 2 = .00055 \text{ (meters)}$. 4. Cooling releases $5 \text{ kg} \times 20 \text{ kcal/kg} = 100 \text{ kcal}$, freezing releases $5 \text{ kg} \times 80 \text{ kcal/kg} = 400 \text{ kcal}$, for total of 500 kcal.

Pressure effects.

Pressure increase on a sample of material can sometimes have the same effect as a temp. increase. Increased pressure can cause melting, for example. An "air" thermometer can give false readings because air volume changes can be due to increased pressure rather than increased temperature. In one respect, pressure cannot replace temperature: in order for a gas to be liquified, one must lower the temperature below a so-called critical temperature. (The pressure needed to liquify at temperatures near the critical temperature is called the critical pressure. A gas at critical temperature and pressure is said to be at the critical point. For carbon dioxide, this point is at about 31 C and 73 atmospheres pressure; for water, it is at about 374 C and 220 atmospheres.)

Boyle's Law says that when a sample of gas is held at constant temperature, volume increases as pressure decreases so that pressure x volume = constant.

Thermometry of gases.

Gay-Lussac found that every gas will expand by about 1/273 of its volume at 0 C, for each degree C of temperature rise, given conditions of constant pressure. The remarkable thing about this result is that it is almost independent of the starting temperature, is almost independent of the given pressure, and is almost independent of the chemical nature of the gas! By extrapolating to lower temperatures, we conclude that at -273 C every gas occupies zero volume. This zero volume temperature is called absolute zero: more precisely it is at about -273.16 C. (This temperature is the starting point on the absolute (Kelvin) scale, which uses the Celsius degree as its unit.)

Insofar as Gay-Lussac's law is true, given conditions of constant pressure the volume of a sample of gas will be directly proportional to its absolute temperature T. This can be stated in the form of Charles' Law : at constant pressure, volume/temp. (absolute temperature) = constant.

Boyle's Law and Charles' Law together imply that for any gas sample, $pV/T = \text{constant}$,
pressure x volume/ absolute temperature = constant.

Kinetic theory of heat.

According to this theory, heat is simply the energy of random "submicroscopic" motions of ultimate particles called molecules. "Kinetic" energy means energy of motion. Ordinary-sized objects have kinetic energy, which comes from the uniform all-together motion of all their molecules. According to the kinetic theory, the left-over individual variation motions of the separate molecules are the energy that we measure as heat.

Week 6 -- NOTES: recap. Page 2

Molecular theory of matter.

The kinetic theory makes sense only if we accept the existence of molecules -- that is, of particles of matter which are essentially indivisible (at least, without destroying the usual properties which we ascribe to substances). The alternative theory would be that at least some matter is infinitely divisible without changing its nature -- for example, that iron -- say -- could be infinitely divided and yet still behave "like iron".

We do have experiences which agree with the molecular theory. For example, an oil slick on a shallow puddle formed on pavement in rain will give a rainbow effect -- very definitely telling us that something is there. But if the puddle's area is increased beyond a certain point, the rainbow will -- instead of fading gradually -- suddenly disappear from part of the puddle surface. This suggests that the slick might really be a single layer of molecules ("monolayer"), because the only dilution possible for a single layer is total absence -- the apparent observed phenomenon.

Another experience, observed under the microscope by a British biologist Brown, is an erratic dance of tiny pollen or other particles, called "Brownian motion". The explanation is that each particle "swims" in a 'sea' whose typical currents cancel each other out, but occasionally there are strong momentary currents from one side or another which cause lurching. The explanation for such currents that is easiest to understand is that this "sea" in fact consists of many -- but not infinitely many -- particles, and that a sudden momentary "current" is due to one of these particles with greater than average energy of motion.

The most consistent evidence for molecules -- that is, the situation in which existence of molecules most thoroughly explains observation -- occurs for the behaviour of gases. The same people that worked on the thermometry of gases also made some crucial observations leading to the molecular theory, observations of chemical reaction of different gases.

Consider chemical reactions of two gases to form a third substance, usually also a gas, at a given pressure and temperature -- say "standard conditions" for example. ("Standard conditions" means sea-level atmospheric pressure -- 760 mm mercury column or about 15 psi or 10^5 N/m² -- and 0°C temperature.)

When carefully measured, complete reactions, consuming all initial ingredients and yielding one end product, were seen to involve volumes of the two gases which were either equal or were in simple ratios to each other. (Gay-Lussac's Law of Equal Volumes -- don't confuse it with Guy-Lussac's other law, above.)

When weights were considered, rather than volumes, reacting gases were also observed to follow a pattern observed in other reactions too: whenever two elements reacted to form a pure compound, their relative weights appeared to follow consistent proportions -- and when different final compound products were formed, the new proportions bore simple relations to the former proportions ("Law of simple multiple proportions"). For example, in forming water, the weights of hydrogen and oxygen are in the ratio 1 to 8, while in forming hydrogen peroxide, the relative amount of hydrogen is observed to double, so that hydrogen and oxygen are in the ratio 2 to 8. In forming carbon dioxide, carbon and oxygen are in the ratio 3 to 8, whereas in forming carbon monoxide they are in the ratio 6 to 8 (all ratios by weight).

All such observations suggested that elemental substances -- "elements" -- are made up of indivisible particles -- called "atoms" -- which come together in consistent numbers of small groups, called molecules, to form other substances "compounds". Thus, apparently, carbon dioxide (its present name reflects our

belief in the theory) consists, apparently, of molecules which each are made up of one atom of carbon and two atoms of oxygen.

This "atom and molecule" theory insinuated (but did not actually say) that for an elemental substance a molecule consisted of exactly one atom: for example, that an oxygen molecule consisted of exactly one oxygen atom. This idea did not square well with another idea suggested by Gay-Lussac's Law of Equal Volumes -- that under given conditions of temperature and pressure, all gases of given volume, independent of chemical nature, had the same number of molecules. In 1811 it was suggested by Avogadro that this second idea (called Avogadro's hypothesis) would work if molecules of elements could consist of more than one atom. Only decades later was it admitted that Avogadro's hypothesis was needed to explain such facts as that two volumes of hydrogen and one volume of oxygen produced two (not one) volumes of water vapor. In fact, most elemental gas molecules consist of two atoms -- and ozone is actually a variant of oxygen with a molecule of three oxygen atoms. (Helium, Neon, and other chemically nonreacting gases have one-atom molecules.)

About fifty years ago, every atom was thought to consist of three kinds of particles: electrically negative charges of negligible mass called electrons, electrically positive charges called protons -- equal in number to the electrons so that the atom would be electrically neutral; -- and electrically neutral particles, of the same mass (very nearly) as protons, called neutrons. The number of electrons (or of protons) is the atomic number; the number of heavy particles -- protons plus neutrons -- is the atomic weight. As the atomic number increases, the atomic weight increases (almost always). Hydrogen, the lightest atom, has number 1 and weight 1 (one electron, one proton, no neutrons). Helium, next lightest, has number 2 and weight 4 (two electrons, two protons, four neutrons). Lithium, next lightest, has number 3 and weight 7 (three electrons, three protons, four neutrons). Actually, the atomic number alone determines the chemical identity of the atom, but sometimes variant weights occur. Heavy hydrogen or deuterium, for example, is hydrogen (number 1) of weight 2 (one proton plus one neutron): deuterium is said to be an isotope of hydrogen. ("Isotope" means "same place" -- in the "periodic table" of the elements.)

Atomic weight measures the number of mass units -- protons plus neutrons -- in an atom. A single one of these mass units is called a dalton (in honor of Dalton, who advanced the atomic theory). The number of daltons needed to equal a gram is called Avogadro's number -- often written N -- and is approximately 6×10^{23} . Avogadro's number of molecules of a substance is said to form a mole of the substance. A mole always has the same mass in grams that an individual molecule of the substance has in daltons. Thus, a mole of hydrogen has mass of 2 grams, and an individual molecule of hydrogen has mass of 2 daltons; a mole of oxygen has mass of 32 grams and a single molecule has mass of 32 daltons (it consists of two oxygen atoms, each with eight protons and eight neutrons).

According to Avogadro's hypothesis, at given conditions of pressure and temperature, a given volume of any gas always has the same number of molecules, independent of the chemical nature of the gas. This means that at given conditions of pressure and temperature a mole of any gas always occupies the same volume, independent of the chemical nature of the gas. In particular, at standard conditions, a mole of any gas occupies a certain volume -- known to be about 22.4 liters (or $.0224 \text{ m}^3$). This is sometimes called a mole volume. A mole is sometimes called a "gram molecular weight".

Week 6 -- NOTES: recap. Page 4

Ideal gases.

Boyle's and Charles' Laws together say that $pV/T = \text{constant}$ for any gas sample. Avogadro's hypothesis says that at standard conditions the volume of any gas sample is determined as (number of moles) $\times$ (mole volume -- standard conditions) -- where the second parenthesis expression equals about 22.4 liters. Therefore we can conclude that for all gas samples whatever,

$$pV/T = 1 \text{ atm. pressure} \times (\text{number of moles}) \times 22.4 \text{ liters} / 273 \text{ K}.$$

Let's write n for the number of moles of the sample, and let's combine all the fixed numerical part into a single constant which chemists like to call R :

$$R = 1 \text{ atm. pressure} \times 22.4 \text{ liters} / 273 \text{ K}.$$

Then $pV/T = nR$, or $pV = nRT$ ("equation of state of an ideal gas", or "ideal gas law").

PROBLEMS ON ENERGY CONCEPTS 7 Feb 1980

1. What potential energy due to gravity and height is in 1 kg water 100 m above ground?
2. If sample in 1. falls, how fast will it hit ground?
3. If sample in 1. has all energy of falling motion converted to heat, what will be the temperature increase?
- 4., 5., 6. Same as 1., 2., 3., where sample is iron, not water.
7. Air travelling at 10 m/s is stopped by 1 m² blades, and all energy in the air stream is converted to energy of rotary motion in the blades and then to electricity. What power (rate of energy delivery) is generated?
8. If 1 hp (horsepower) is about 3/4 kW, how many hp are being furnished?
9. What happens if in 7 and 8 10 m/s is replaced by 5 m/s? Discuss implications for fans and wind generators.

MORE PROBLEMS

1. Heat is supplied to an engine at 227 C and is rejected at 27 C. What is the maximum possible thermal efficiency?
2. A heat pump uses 1 kW to deliver 1 ton (12,000 btu/h). What is its COP (coefficient of performance)?
3. A heat pump uses a ground water source at 10 C to deliver heated water at 45 C. What is the maximum theoretical COP?
4. 10 kg water at 0 C exchange heat with 10 kg water at 50 C, so that the cold water gains 1 C and the hot water loses 1 C. What is the gain in entropy?
5. Estimate the gain in entropy in 4 if the two water samples were totally mixed.

Experts' Tool for Calculating Conservation Gains

Heating Degree Days: Comparing Winters

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total	Heating Season*
1976-77	24	52	81	307	510	625	786	451	591	335	320	79	4161	3605
1977-78	34	43	178	390	625	701	631	525	498	447	323	78	4473	3817
1978-79	44	42	180	324	706	846	837	630	479	420	235	96	4839	4242
1979-80	27	40	86	327	628	742	—	—	—	—	—	—	—	—
20-Yr. Avg.	51	57	156	378	587	757	783	595	610	480	308	140	4892	4488

NOTES: Heating degree days, as reported by the National Weather Service for the Sea-Tac Airport weather station. The "heating season" totals are for the months from October to May.

E 150 Week 7

Heat exchangers--

Basic questions to be answered. (have class develop others)
(and seek to answer all questions)

Why? What to what?

How they work? Importance of surface area. Convective transfer.

Examples: fan-coil
dhw-solar tank coil
rock bed. Solar

Heat movers.

1. Forced convection - fans, pumps
2. Wat. convection, "Thermosyphoning" - How does it work. How to make it useful. Advantages, disadvantages
3. Heat pumping and refrigeration. How do these work - review COP
How to make useful. Pros, cons.

E 150 - Week 8

Heat generators.

What kinds do we know?

How do they work?

Combustion. What is it? What happens? Stages of combustion - wood, coal, gas...

Stoves. What happens? What do we design for?

Combustion engine cycles.

Draw P-V (or P-T or V-T) diagram.

Compare with Carnot cycle.

Basic operation of engines

recall use of engines for mech. and elect. power.

All modes of heat transfer (radiation, conduction, convection) basically satisfy the "Newton law of cooling" (or of "heating" or of "heat loss"): transfer rate Q = constant $\times \Delta T$.

where ΔT = source temp. minus environment temp.

when the source (as is usual) has a surface area through which heat is transferred, we can say:

$$\text{HEAT TRANSFER RATE} = \text{"COEFFICIENT"} \times \text{AREA} \times \Delta T$$

(another constant)

$$Q = U \times A \times \Delta T$$

The coefficient is a per-unit-area rate of heat transfer (per temp. degree difference).

The coefficient actually depends on the nature of the material and its thickness. (When transfer mode is conduction we call U the conductance.) $\frac{1}{U}$ is called resistance.

Resistance is proportional to thickness:

$$\text{Resistance } R = \text{thickness} \times \text{resistivity } R_0$$

(resistance per unit thickness)

$$\frac{1}{R_0} \text{ is called } \underline{\text{conductivity}} \text{ } k \text{ (or analog for other modes than}$$

$$\text{conductance} = \text{conductivity/thickness}$$

$$U = k / \Delta X$$

$$\text{so } Q = UA \quad T = kA \quad T / \Delta X$$

$T / \Delta X$ is called the temp. gradient - it says how fast the temp. falls (or rises).

We have: Heat transfer rate = "conductivity" x area x gradient.

$$Q = kA \Delta T / \Delta X$$

Problem: It's 65F inside, 35F outside.

How many btu/hour are lost through a rigid-insulation door, $2 \frac{1}{2} \times 6 \frac{2}{3}$ feet, made of R-6 per inch material, 2 inches thick?

What are the conductance, conductivity, resistance, resistivity, gradient?

This discussion is right for conduction mode. Convection and radiation need modification. They each depend not on the in-depth property of materials but rather on the properties of the actual surface or area through which heat is transferred. So there is no real analog for conductivity, resistivity, gradient. So we go back to:

$$Q = U \times A \times \Delta T$$

and when we talk about convection we use the "convection coefficient", usually written h .

$$Q = h A \Delta T$$

h depends on nature of two substances which come together at the transfer surface, and their motion (velocity). Convection coefficients are only approximately known [= 1 to 5 for water to quiet air, for example, in British units.]

ENERGY 150

	CONCEPT	UNITS OF MEASUREMENT S.I. (METRIC)	
m	MASS of an object 1 cm ³ water has mass 1 g 1 liter water has mass of 1 kg	GRAM (g) KILOGRAM = 1000 g = 1 kg TONNE = 1000 kg = 10 ⁶ g	POUND 454 g 2.2 lb
d, s l	(DISTANCE between points (LENGTH of an object)	METER (m) KILOMETER = 1000 m = 1 km (CENTIMETER = .01 m) MILLIMETER = .001 m = 10 ⁻³ m MICROMETER = 10 ⁻⁶ m NANOMETER = 10 ⁻⁹ m (ANGSTROM = 10 ⁻¹⁰ m) PICOMETER = 10 ⁻¹² m	39.37 in 40 in MILE 1.6 km INCH = 2.54 cm 2 1/2 cm FOOT = 12 in 30.5 cm .3 m
t	TIME - SECOND (s or sec), HOUR (hr or h)		
v	(SPEED (VELOCITY (directed speed) speed of light	METERS PER SECOND m/s DISTANCE/TIME 300,000 km/s 3 x 10 ⁸ m/s	ft/s MILE/HOUR
a	ACCELERATION (pickup) (rate of change in speed) gravity	SPEED/TIME METERS PER SECOND, PER SECOND (m/s)/s 9/8 m/s ² 32.2 ft/s = m/s ²	ft/s ²
F	FORCE (driving an object = MASS x ACCELERATION (according to Newton weight of an object = mass of object x gravity	MASS x ACCELERATION kg x m/s ² , = 1 kg - m/s ² = 1 Newton (N)	POUND force = POUND - MASS x GRAVITY = weight of one-pound mass
W	WORK (against a force) force x distance moved against it	FORCE x DISTANCE N - m = kg - m ² /s ² = 1 Joule (J)	16- force x 1 foot = ft - lb
KE	KINETIC ENERGY (of a moving object) (work object can achieve by being stopped)	MASS x VELOCITY ² KE = 1/2 mv ² a kg mass going 1 m/s has 1/2 J of KE	
PE, V.U	POTENTIAL ENERGY PE + KE = constant		

System design.

Energy conservation.

Let's review all the techniques for energy efficient building design and relate them to what we've learned, and vice versa. Generate list. (in class)

e.g. insulation - lowered heat transfer to outside, thus keeping temp. in comfort zone longer.

thermal mass - (same result)

heat pumps - with long term COP greater than 1, it saves over direct conversion of input energy to heat.

Let's note other tactics which our knowledge can suggest, even though they're not common practice. For example, on-site booster - heat from low temp. water storage tank. Why can this save energy? Pros, cons.

Review.

Sample Final.

HEAT TRANSFER (The first pages of these notes replace the two dittoed pages handed out in class on 28 Feb. 1980.)

All modes of heat transfer (radiation, conduction, convection) basically satisfy the "Newton law of cooling" (or of "heating" or of "heat loss"):

$$\text{Transfer rate } Q = \text{constant} \times \Delta T$$

where ΔT = temperature difference = source temperature minus environment temperature.

Usually, the source has a surface area A through which heat is transferred. We can then say that

$$\text{Transfer rate } Q = \begin{array}{c} \text{"coefficient"} \\ \text{(another constant)} \end{array} \times \text{area } A \times \text{temp. diff. } \Delta T.$$

The "coefficient" is a per-unit-area rate of heat transfer (per degree of temp. diff.). Let's now look at each mode separately and go into details.

Conduction. In this case the coefficient is called conductance, and is written U . $1/U$ is called R , the resistance.

Since U expresses per-unit-area rate of heat transfer per degree of temperature difference, appropriate units for U are:

$$((\text{btu}/\text{hour})/\text{ft}^2)/^\circ\text{F} \quad \text{or} \quad ((\text{kJ}/\text{sec})/\text{m}^2)/^\circ\text{C}.$$

Comment
on
math,
units,
&
format

Remember that whenever we write "/" we could equally well write "____" or "÷", and we can say either "per" or "divided by".

It is important to be sure that we get straight the order in which successive divisions are performed -- and use parentheses or well-understood conventions to be sure. Otherwise, we might be due for confusion. For example, is $20/10/2$ supposed to mean $(20/10)/2$ or $20/(10/2)$? The first number is $2/2$ or 1 , the second number is $20/5$ or 4 .

To keep everything straight, it is possible to replace successive divisions by one division and several multiplications -- being sure to use parentheses to keep straight the difference between, for example, $(20/4) \times 5$ and $20/(4 \times 5)$.

Thus, instead of writing $((200/5)/4)/2$ we can write $200/(5 \times 4 \times 2)$.

Similarly, we can write the unit for U as $\text{btu}/(\text{hr} \times \text{ft}^2 \times ^\circ\text{F})$.

When working with units (rather than numbers), we often use a hyphen or a dot to indicate "times", rather than writing "x", because we actually don't say anything between the names of units which are being multiplied together.

Thus, we can write the unit for U as $\text{btu}/(\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F})$. The metric unit can be written as $\text{kJ}/(\text{sec} \cdot \text{m}^2 \cdot ^\circ\text{C})$ or $\text{kJ}/(\text{sec} \cdot \text{m}^2 \cdot ^\circ\text{C})$.

The metric unit can also be written using the idea that kJ/sec is just kW , so that we have $\text{kW}/(\text{m}^2 \cdot ^\circ\text{C})$.

The idea, $\text{kJ}/\text{sec} = \text{kW}$, is a way of saying that a "heat transfer rate" is another version of "power", = "rate of energy delivery".

There can be more than one correct way for writing the same unit. For example, the unit for U can also be written as $(\text{btu}/\text{hr})/(\text{ft}^2 \cdot ^\circ\text{F})$.

Now let's get back to the real ideas about heat. In conduction, what is happening is that the temp. difference ΔT occurs as the heat passes through a (real or conceptual) slab of given material of area A and thickness commonly denoted Δx (for "difference in x-position").

The temp. difference ΔT occurs through the thickness Δx . The rate at which temp. falls through the slab is $\Delta T/\Delta x$. This rate is called the temperature gradient.

When we say that heat flows from hot to cold, a more precise and quite believable statement in the case of conduction is that heat flows in response to a temperature gradient. The flow is directly proportional to the gradient as well as the area through which flow occurs:

$$Q = \text{constant } k \times \text{area } A \times \Delta T/\Delta x = \text{conductivity} \times \text{area} \times \text{temp. gradient.}$$

The constant k is called the conductivity. It depends just on the material through which conduction is occurring. (Strictly speaking, it will depend on the temperature and on other things too, but the basic idea is that it is a property of the material.) Conductivity is independent of the thickness of the slab.

Now, let's rewrite the above equation to the form:

$$Q = (k/\Delta x) \times A \times \Delta T.$$

We see that since we also have

$$Q = U \times A \times \Delta T,$$

it must be that the conductance U is the same as the conductivity k divided by thickness Δx . In particular, when Δx is of unit thickness, U and k have the same value.

The unit of k has to be so that the above equations work. We have

$$k = (Q \times \Delta x) / A \times \Delta T,$$

so the unit of k is expressible in units of (heat loss $\times$ length) / (area $\times$ temperature).

In the metric units, k is expressible in units of $(\text{kJ} \cdot \text{m}) / (\text{m}^2 \cdot ^\circ\text{C})$, or simply $\text{kJ} / (\text{m} \cdot ^\circ\text{C})$.

In British units, k is expressible in units of $((\text{btu/hr}) \cdot \text{in.}) / (\text{ft}^2 \cdot ^\circ\text{F})$ or sometimes more simply in units of $((\text{btu/hr}) \cdot \text{ft}) / (\text{ft}^2 \cdot ^\circ\text{F}) = \text{btu} / (\text{hr} \cdot \text{ft} \cdot ^\circ\text{F})$.

Problem. With 65F inside, 35F outside, how many btu/hour are lost through a rigid-insulation door of size 2.5 x 6.6 feet made of R-6 per inch material 2 inches thick?

Solution. We want Q , where $Q = U \times A \times \Delta T$. We find that $\Delta T = 30\text{F}$, $A = 16.5 \text{ ft}^2$, and $U = k/\Delta x = k/(2 \text{ inches})$. We need only find k .

The problem says that the material has R-6 thermal resistance per inch thickness, so that an inch-thick slab has $U = 1/6$. So k has the value $1/6 ((\text{btu/hour})/\text{in.})/(\text{ft}^2 \cdot ^\circ\text{F})$.

Then U has the value $(1/6)/(2 \text{ in.}) ((\text{btu/hour})/\text{in.})/(\text{ft}^2 \cdot ^\circ\text{F}) = (1/12) \text{ btu}/(\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F})$.

Then Q has the value $(1/12) \times 16.5 \times 30 \text{ btu/hour} = 41.25 \text{ btu/hour}$.

Review this problem and determine just what are the conductance, conductivity, resistance, resistivity ($= 1/(\text{conductivity})$) and temperature gradient.

Conduction -- several layers. Suppose the "slab" through which heat is transferred is a "sandwich" consisting of several layers. The basic working fact which can be obtained from the statement that heat loss = conductivity x area x gradient is that resistances of the separate layers of the sandwich can be added to get the resistance (that is, $1/U$, where U is the conductance) of the entire sandwich.

This is the basic idea behind heat-loss calculations.

Problem. Determine the layers which make up the "sandwich" of a typical wall section in your house. Use whatever tables you may have to determine the resistances of the separate layers. Then determine the overall conductance of the wall section.

Convection. The above discussion works for convection, except that convection depends not necessarily on the property of a slab of material but rather on the properties of the actual surface through which heat is transferred. We can go back to the equation

$$\text{Heat transfer rate } Q = U \times A \times \Delta T$$

but now instead of conductance U we can use another letter and speak of the convection coefficient h , so that we can write:

$$Q = h \times A \times \Delta T.$$

The value of h depends on the nature of the two substances which come together at the transfer surface, and their motion. Even the best common tables give only approximate values, since so many variables (especially concerning motion) are present in any particular situation. For example, in convection between water and relatively quiet air, h has the tabulated value range of 1 to 5 (in units of $\text{btu}/(\text{hour} \cdot \text{ft}^2 \cdot ^\circ\text{F})$).

Several layers. One can proceed to analyze for a several-layered sandwich what the overall heat transmission coefficient (now called U again) is: again, we use the idea that $R (= 1/U)$ is the sum of the separate resistances of the separate layers. Of course, in some cases (like an air space) the main heat transfer effect through the layer will be due to convection rather than conduction, and so we must use "convective resistance" ($= 1/h$).

More generally, across any layer in the sandwich, there will be a certain contribution of heat transfer due to conduction and a contribution due to convection: these must be added to get the overall U -value. Then, the overall resistance of the layer will be $1/U$ (overall U -value). Then, one adds the several resistances of the layers.

Problem. A "sandwich" consists of three layers with the following specifications.

Layer 1 .5 inch thick, R-6 per inch for conduction; .05 $\text{btu}/(\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F})$ convection coefficient.

Layer 2 2 in. thick, convection coefficient = 1.5; conductivity = .05.

Layer 3 .1 $\text{btu}/(\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F})$ convection coefficient; conductive resistance = 8.

Determine the heat loss through 10 square feet with $\Delta T = 15^\circ\text{F}$.

Radiation: Here the basic mechanism is easy to understand, yet complex indeed to work out in any situation. Every surface radiates electromagnetic energy, in different "wave lengths", at the speed of light (about 3×10^8 m/sec.). For any given surface, the amount of energy emitted in given time depends on the temperature. In fact, one investigator, Stefan, found that the amount emitted is proportional to the fourth power of the absolute temperature, as well as to the area of the surface and to the quality of the surface as an emitting surface. (This quality, the emissivity, is between 0 and 1, 1 meaning a perfect so-called black-body emitter). In other words,

$$Q_{\text{out}} = \epsilon A T^4$$

where T is absolute temp., A is area, ϵ (epsilon) is emissivity, and σ is a universal constant (σ , = "Stefan's constant").

At the same time, the same surface is receiving energy from other radiating sources. The fraction of received energy from other sources that is actually accepted ("absorbed" or perhaps, in the case of transparent material, also "transmitted") depends on the nature of the material. In the case of an opaque surface (no transmission possible), we can say

$$Q_{\text{in}} = \alpha (\text{total } Q \text{ received}).$$

The fraction, (alpha), between 0 and 1, is the absorptivity.

In any case, $Q_{\text{out}} - Q_{\text{in}}$ represents the net rate of heat transfer from the surface.

In one special case, we can say that this net rate of transfer indeed has the form

$Q = \text{constant} \times \text{area} \times T^4$. Here, the transferring surface, and another such surface, form the two sides of a slab of empty space; and T refers to the difference in temperature between the two sides. Moreover, the two surfaces are assumed to have the same emissivity and absorptivity. Then we have:

$$Q = \text{constant} \times A \times T^4,$$

provided that T is not too large. The actual value of the "constant" is about $4 \times 10^{-8} \text{ W/m}^2\text{K}^4$, where T is the average of the absolute temperatures of the two surfaces.

Radiation -- supplier of energy to the earth and remover of energy from the earth.

Since calculations of heat losses involving radiation is so complicated, modern engineered heating systems have tended to shy away from exploiting the benefits of well-designed heating systems where comfort is obtained by radiant heat transfer to human skin and clothing. This is a great pity -- and represents a great opportunity for the near future, for understanding heating and for achieving more comfortable -- and at the same time far more energy-efficient -- heating systems.

At any rate, radiation is the fundamental mode of heat transfer to and from earth. In the book Energy and Environment, by Thorndyke (Addison Wesley 1976) there are relatively brief computations which allow one to explain earth's average temperature largely in terms of the intensity of solar radiation (about 1.5 kW/m^2 in outer space near earth in direct line of the sun's rays), using Stefan's law and some geometry. The basic idea is that earth too is a source of radiation -- and essentially reradiates enough from its entire surface to balance the solar radiation which is coming in from one side.

Moisture. It's worth considering a bit just what we know about heat tells us about moisture. Air contains water vapor -- that is, H_2O gas (not just tiny droplets of water too small to see, but actual molecules of H_2O as a gas).

Unlike other gases in air, H_2O is fairly close to its freezing point, and the air cannot sustain much gaseous H_2O . Unlike other gases, the amount of H_2O which the air is capable of including is very dependent on temperature, with higher temperature much more capable of including more H_2O gas.

Hence, we have a phenomenon of condensation: warm air, carrying a goodly fraction of moisture, can no longer carry this moisture when cooled.

Hence, in any situation where ~~moving~~ ^{cooler} air will cool, there is the possibility that moisture in the air will condense. In particular, if air spaces in insulation or in wood or elsewhere are the places for such a path for moving air, there is the danger of condensation which will do damage.

Moreover, even when the air "itself" won't move into cooler places, there is always the possibility that the water vapor will be able to find its way into those places; then, in the cooler air less supportive of vapor, some of the new vapor there may condense, again perhaps doing damage. This possibility of vapor itself making its own way is like heat moving from hot to cold. In place of a temperature gradient, the motivating "force" is a "pressure gradient" -- that is, decrease of pressure (due to the vapor), as one moves from where the vapor already is to where it is trying to go. In place of the equation

$$\text{Heat transfer} = \text{conductivity} \times \text{area} \times \text{temp. gradient},$$

we get an equation of the form

$$\text{Vapor transfer} = \text{permeability} \times \text{area} \times \text{pressure gradient}.$$

When suitable units are chosen for pressure, etc., the resulting unit of permeability is called a "perm". (A good vapor barrier ought to rate 1 perm or less.)

QUESTIONS FOR DISCUSSION

1. Describe how a "thermos" bottle or Dewar flask insulates its contents.
2. In what situations do you want pipes or other surfaces of enclosures to serve as heat exchangers? Name as many of these situations as you can.
3. Consider factors affecting choice of heat exchangers. Materials? Costs? Area of exchange surface? Movement of fluids on one or both sides of exchanger? How do each of these factors and others come in?
4. Compare radiant and convective delivery of heat in as many ways as you can: comfort, cost, efficiency for given result, ... in as many situations as you can.
5. Now that you know quantitative forms of the fact that heat moves from hot to cool, summarize the benefits and disadvantages of lower temperatures in domestic water tanks.
6. Trace exactly the reasoning which leads to the observation that unmixed water in a tank will "stratify" with hottest on top.

SUPPLEMENTAL INSTRUCTIONAL MATERIALS

ENERGY 150 - FUNDAMENTALS OF HEAT TRANSFER

Instructor: Joe Weinstein 325-6710.

Prerequisites: Energy 100, high school physics
Credit: 5 credits. or instructor consent.

This course is designed to serve persons interested in the energy field, and in particular is designed to help students become familiar with concepts and ideas underlying Energy 210 (Energy Auditing/Calculations), and other Energy courses on mechanical systems and on conservation and solar design. (Courses 170, 110, 130.)

Description: Heat and heat flow: principles, measurements, and applications in energy system design and operation. Topics include: heat and temperature, thermodynamic laws, thermal properties of materials, heat transfer, heat recovery and cogeneration, heat engines and power generation, refrigeration and heat pumps.

Students will become familiar with formal definitions and practical measurement of basic concepts concerning heat and heat flow, including: quantity of heat, temperature, heat capacity, specific heat, conductivity, power, efficiency, coefficient of performance.

Students will also become familiar with basic principles governing heat flow, and their implications for methods of energy conservation and delivery, and for the consequent proper design of conservation and delivery systems.

Instruction methods will include: lectures, demonstrations, discussion, home-study problems. Student evaluation will be based on: quizzes 25%, notebook and projects 25%, midterm 20%, and final 30%.

OUTLINE

Week (Tu. date)

1. 1/1 (start 1/3) Introduction. Course scope and objectives. Intro. to temperature, heat, heat capacity, flow. Units, measurements, temp. scales.
2. 1/8 Physical properties, First Law. Thermal expansion, phases. Molecular picture. Ideal & other gases. Conservation law, implications.
3. 1/15 Second law. Statements, implications. Carnot engines, efficiencies.
4. 1/22 Basic heat transfer: conduction. Fourier & Newton laws, everyday implications. Conductivity. R-value concept.
5. 1/29 (MIDTERM 1/30) Basic heat transfer: convection. Convection in nature, convective losses. Considerations of moisture and humidity.
6. 2/5 Basic heat transfer: radiation. Radiation, absorption, emission. Blackbody. Earth's energy balance. Human comfort.
7. 2/12 Heat exchangers and heat moving devices. Exchangers. Mech. heat & cooling. Natural heating & cooling. Refrigeration & heat pumps.
8. 2/19 Heat generators and heat convertors. Combustion, furnaces, stoves. Heat engines for mech. & elect. power.
9. 2/26 System design and energy conservation techniques. Heat recovery, cogeneration, lower-temp. reservoirs with site booster-heat, etc.
10. 3/4 (no class 3/6) Additional or review, as desired.
11. 3/11 Additional or review, as desired.
12. 3/18 FINAL

REFERENCES

"Text" for this course will be instructor notes. These will usually include a week's advance of brief text, questions for discussion and followup, questions for exploration, and problems for computation.

For background and alternative treatments, consult your "favorite" high-school physics texts -- their sections on "heat" -- at least for the first part of the course. Consult your own experiences! Think of your own questions as well as those handed out!

FIRST STEPS IN THE STUDY OF HEAT

Why study heat?

Heat is our basic end use of energy (that is, purchased energy). We use "low temperature" heat for homes and buildings, and "industrial process" heat to refine materials and manufacture products. Most of our remaining uses of energy -- primarily transportation -- use heat energy as a source for needed mechanical energy.

Where does our study begin, and what does it involve?

We begin with our direct experiences. We know that we perceive "hot" and "cold", or at least "hotter" and "colder". At any given time and place we seem to feel a certain "level of hotness". This "level" of hotness seems to be an objective reality. We also imagine that when we feel "hotness" increasing or decreasing, there is actually an (invisible but quite "real") substance or material called "heat" which is being added or removed.

These experiences raise questions. Is there a way of specifying what is "really" hotter or colder? Is "level of hotness" indeed an objective concept? If so, how can hotness levels be established or measured? Can changes in "hotness" consistently be ascribed to addition or removal of a "thing" called "heat"? If so, how can we measure "heat" and how can our measurements be used to predict observed changes?

These and related questions, considered in detail, lead to an outline of our study.

1. What do we really directly experience of "heat"?

Locke's three-basin two-hands experiment suggests that we observe relative changes more reliably than absolute levels of "hotness".

2. Do we observe consistent changes in matter associated with heating or cooling?

Heating seems to account for changes of phase from solid to liquid, or liquid to gas. Heating seems to lead to expansion in most materials, with only one major exception: a change from ice to ice-water, or from ice-water to warmer but still very cold water, actually involves contraction, not expansion.

3. Is "level of hotness" really a consistent concept? That is, whenever we observe one "symptom" of a given level can we observe it and other symptoms, repeatedly, time after time?

When one sample of water freezes, so does another one (kept close to it). If the samples freeze in the presence of an enclosed tube in which liquid (mercury or alcohol, say) is at a certain mark, later freezings of the samples will occur when the liquid is at that same mark.

It is thus consistent to speak of a given "level of hotness". We call such a level a "temperature". Any device which we use to measure or specify temperature is called a "thermometer", and its use is called "thermometry".

4. What kind of thermometers are there? How do they work?

A typical thermometer makes use of above-noted "thermal expansion" of materials. A liquid or gas is enclosed in a glass-walled container, and -- on heating -- must expand inside a tube. Mercury is used as the liquid in a standard thermometer. Galileo used air, trapped inside the glass by a water reservoir.

Another "thermal expansion" thermometer is a "bimetallic" strip, which bends with heat on account of the different rates of expansion of the two metals.

Effects of heat on electrical conduction are used by various electric or electronic thermometers. Yet other effects are used in other thermometers.

5. Does it make any difference what sort of thermometer is used to record temperature?

As long as we simply wish to specify the level of hotness (temperature) without making inferences from numbers, we may use any available thermometer. But once we start making calculations involving temperatures -- beyond a mere statement that one recorded temperature is "hotter" or "colder" than another -- the particular choice of thermometer may make a difference. See 7.

6. Must numbers be used to record temperatures? Is there any advantage in using numbers?

There is no logical necessity to use numbers to record temperatures: as long as we can tell, of two recorded temperature, which is higher ("hotter") and which lower ("colder"). For work with the usual types of thermometers, using numbers is very natural and convenient. In effect, the measurement of temperature is reduced to measurement of length. See 7.

7. How can we (numerically) measure temperatures?

For everyday applications, start with a mercury thermometer which will record temperatures between the freezing point of water (that is, the temperature where water and ice co-exist) and the boiling point (where water and steam co-exist).

Use the Celsius method (or "scale"): divide the thermometer into 100 equal lengths between freezing and boiling point marks. Each length is called a "degree", the freezing point represents 0 degrees, boiling represents therefore 100 degrees. In abbreviation we use $^{\circ}\text{C}$ or just C for "degree" by the Celsius method.

Alternatively, use the Fahrenheit "scale": use 180 rather than 100 lengths between freezing and boiling, call freezing 32 degrees (so that boiling is 212 degrees), and write $^{\circ}\text{F}$ or F for "degree" by the Fahrenheit method.

If some liquid other than mercury were used in such measurement, say alcohol, the meaning of the numerical readings would change slightly (because of slightly different expansion properties of the other liquid). In particular, a reading of 50 on an alcohol thermometer marked by the Celsius method would not occur quite at 50°C . Since the choice of mercury as standard liquid is somewhat arbitrary, the recent precise definition of temperature measurement uses a different approach than just noted -- but the difference can be neglected for most practical applications.

8. Besides Celsius and Fahrenheit "scales", what others are used?

Theory and experiment indicate that there is a coldest possible temperature, "absolute zero". Using recent definitions, absolute zero turns out to be at about -273°C or about -459°F . The Kelvin scale uses the Celsius degree as the unit (but renames it the "Kelvin degree", or, simply, the "kelvin", K) and starts its count at absolute zero. Thus, 273 K is the freezing point of water and 373 K is the boiling point. The Rankine scale uses the Fahrenheit degree (but renames it the "Rankine degree", R) and starts its count at absolute zero, so that $459+32 = 491\text{ R}$ is the freezing point and $459+212 = 671\text{ R}$ is the boiling point.

9. Do temperature numbers really mean anything?

This vague question stands for several more precise and important questions.

In particular, what meaning is there to taking two temperature numbers and adding them? or taking their difference? etc.?

What relationship does recorded temperature have with the amount of "heat" present in a substance? Can temperature increase be used to predict expansion?

These and other related questions will be considered in what follows.

10. Can temperature increase be used to predict amount of "thermal expansion"?

Expansion is measured in terms of fractional increase along a given dimension of whatever thing is being considered. For example, suppose an iron bar 1 meter long by 10 cm by 5 cm is heated so that its length is 1.01 meters (or 101 centimeters). We then say that the linear expansion of the length is .01 meters and along its length the bar has undergone a fractional expansion of .01 (it is longer by .01 of its original length).

It is experimentally observed that the fraction of linear expansion depends on the particular substance, but generally does not depend on the particular dimension. Thus, the 10 cm and the 5 cm thicknesses of the bar are also expanded by .01 (or 1%) of the original sizes, to become 10.1 and 5.05 cm.

It is also experimentally observed that, for very small temperature increases, fractional expansion is proportional to the size of increase; further, that for a given amount of temperature increase, fractional expansion is almost independent of the starting temperature (if it is a typical "everyday" temperature).

Therefore, to predict expansion during heating, we need know only: the nature of the material, and the amount of the temperature increase. The so-called linear expansion coefficient of a material (often called α , alpha) is the linear fractional expansion coming with a 1°C temperature increase. Once we know this coefficient, we can compute the actual linear expansion:

$$\text{Expansion} = \text{coefficient} \times \text{temperature increase (in degrees C)} \times \text{original length.}$$

Note that volume will expand by a fraction about 3 times the fraction of linear expansion. For example, a cube 1 meter on a side which expands to 1.01 meter on a side will have expanded to a volume of just over 1.03 cubic meters.

In most problems, the only quantity unknown from givens or experiment will be the coefficient of linear expansion. This coefficient is tabulated for common substances in most handbooks. See our tables here too.

11. How does numerical temperature accord with the idea of "heat"?

Our concept of "heat" is that it is "something" whose addition or removal makes things hotter or cooler.

The one justification for thinking of "heat" as "something" is that, presumably, the total amount of heat is not changed in a typical process.

Suppose we take 1 liter of water at 40 C and 1 liter of water at 20 C, and quickly (to avoid heat loss to the outside) mix them to form 2 liters of water. What should be the temperature of the resulting mixture?

If our idea of heat makes any sense, and we have mixed quickly yet carefully, the resulting mix should have as much "heat" as the sum of the quantities of heat contributed by the two separate liters.

Moreover, if our idea of heat as reason for "hotter" makes sense, the higher temperature of the 40 C water ought to be accounted for by the presence in that water of more heat units than in the 20 C water.

The observed mix temperature, 30 C, is what would result if -- in effect -- it took as much heat to raise the temperature of the cooler water by 10 C as it took to lower the temperature of the warmer water by 10 C. That is, the fact that we observe an averaging of temperatures is consistent with two simple ideas: heat is conserved, and equal temperature changes (at least of equal amounts of similar substance) result from addition or removal of the same amount of heat.

Note, by the way, that to obtain the temperature of the mix it would be nonsensical to add the temperatures of the separate liters: the mix is not at 60 C, it is not warmer than either of the separate liters!

Even in situations where it seems to make sense to add temperatures, think again just what scale should be used. If we add 20 and 40 to get 60 -- in the Celsius scale -- we should add 293 and 313 (in the Kelvin scale) and get 606 in the Kelvin scale. But a temperature of 60 C is actually quite different from a temperature of 606 K (= 333 C)!

On the other hand, both the above discussion and the discussion on thermal expansion show that temperature differences and averages are in general meaningful, and the answers are independent of the temperature scale used.

12. How can heat be measured?

From above, we find that for a given amount of given substance heated by a given temperature increase, a fixed amount of heat is required. (Strictly speaking, this conclusion depends somewhat on the starting temperature and other experimental conditions, but such qualifications can wait.)

Hence it requires a given amount of heat to raise one kilogram (or one liter) of water by 1 degree C. This amount is called a kilocalorie (kcal).

It requires a given amount of heat to raise one pound (or about one pint) of water by 1 degree F. This amount is called a British Thermal Unit (btu).

The btu and kcal are our fundamental units of heat. Their very definition allows direct measurement of amounts of heat in many situations. The word "calorie" derives from "caloric" or "heat substance". A "calorimeter" is a device for measuring changes in amounts of heat, and such measurement is called "calorimetry".

13. Does it make a difference that water was used in the above definitions?

Yes! It would take some other number of btu to raise a pound of iron or of alcohol by 1 degree F. Each substance has a characteristic number of btu per pound needed to raise temperature by 1 degree F -- also the same as the number of kcal per kilogram needed to raise temperature by 1 degree C.

This number is called the specific heat capacity of the substance. (Strictly speaking, the number depends a bit on temperature and other experimental conditions, but such qualifications can wait.)

Why do we speak of "capacity"? Because, by being warmed 1 degree F (say), a substance is in effect storing so much heat (per pound of material). The specific heat capacity of a substance is essentially a comparison, with water as the standard, of the substance's ability to store heat by means of a temperature increase.

Specific heat capacities can be determined by careful experiment, and are tabulated for common substances in most handbooks. See our tables too.

14. How can specific heat capacity be used to calculate heat gained or lost in a temperature increase or decrease?

We can say: $\text{heat gain} = \text{temperature increase} \times \text{amount of substance} \times$
 $\times (\text{heat gain per degree per mass-unit})$

and the quantity in parentheses is just the specific heat capacity.

15. Are temperature changes the one way a substance can gain or lose heat?

No. Above we observed that heating (that is, supplying heat) seems to account for changes which need not involve temperature change, namely changes of phase. For example, we can start with ice at 0 C (and know that it isn't any colder, because a little bit of water coexists with it) and melt it to ice-water (still at 0 C). It takes about 80 kcal per kilogram of ice to achieve this phase change: in other words, as much heat as is needed afterwards to raise the ice-water to 80 C, or 80% of the way to boiling! The amount 80 kcal per kilogram is called the latent heat of fusion of the ice. (The extra amount of heat in ice-water, as opposed to ice, is called latent because it is "hidden" and not made visible as a temperature change. Heat which is manifest by temperature change is, by contrast, called "sensible" -- that is, capable of being sensed directly.)

Latent heats of phase changes of various substances can be determined by careful experiment, and are tabulated for common substances in most handbooks. See our tables too.

Practical Thermodynamics

THERMAL PROPERTIES OF MATERIALS -- Based on various tables in physics texts.

MATERIAL	Specific heat (15-100C range, for solids)	Melt. point	Heat of fusion	Boil. point	Heat of vapor'n.	Coef. of expansion (linear, in millionths, for solids; cubical, in thousandths for liquids).
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(Degrees and temperature unit are Celsius.)

Solids at room temp.

Aluminum	.22	660	77	2057	2500	24
Brass	.09					20
Brick	.12					
Carbon	.17					
Copper	.09	1083	49	2336	1150	14
Glass	.20					4-9
Pyrex						3
Gold	.03	1063	16	2500		14
Invar						0.9
Iron (cast)	.11	1535	8	3000	1600	11
Steel						8-13
Lead	.03	327	6	1620	207	29
Porcelain						0.4
Quartz						3
Silver	.06	960	26	1950	565	18
Tin	.06	232	14	2270		
Tungsten	.04	3370	43	5900	1180	
Zinc	.09	419	23	907	423	26
Rubber	ca. .20-.25					

Liquids at room temp.

Bromine	.11	-7	16	60	46	
Carbon tet.	.20	-23		77	46	
Ethanol	.58	-115	25	78	204	.75
Ethylene glycol						
Glycerine	.60					.49
Mercury	.03	-39	3	357	71	.18
Petroleum						.90
Water	1.00	0	80	100	540	
Ice	.50					
Steam	.48					

Volume of water is 1.0000 at 4C.
(1.00013 at 0 C, 1.0027 at 10 C,
1.00177 at 20, 1.012 at 50,
1.026 at 75, 1.043 at 100 C.)

215

Gases at room temp.

Ammonia	1.1	-78	84	-33	327	
Carbon Dioxide						
Chlorine	.14	-101	22	-34	69	
Hydrogen	3.4	-259	14	-253	108	
Nitrogen		-210	6	-195	48	
Oxygen		-219	3	-184	51	

216

182

Practical Thermodynamics

EXPERIMENT OR DEMONSTRATION

Conducted by:

Recorded by:

Title:

Place, date, time :

Purpose (question to be resolved, or hypothesis to be tested):

Equipment and materials:

Procedure:

Observations:

Discussion (resolution of question or hypothesis, remaining questions, conclusions, recommendations for further testing):

TESTING EVALUATION

ENERGY 150 - FUNDAMENTALS OF HEAT TRANSFER

Fill in the blanks with appropriate words or quantities:

1. The amount by which a sample of a given substance expands when heated depends on the original dimensions, on the substance's _____ and on the _____.
2. When room temperature is held constant and a sample of warmer material is cooled, the rate at which the sample loses temperature _____ with time (increases, decreases, stays the same, varies without any rule).
3. Two liters of water, originally in the same container at 30 C, are poured without being heated or cooled into separate liter containers, one of which is later observed to be at 20 C and the other of which is observed to be at 40 C. This observation _____ the first law of energy and _____ the second law of energy (affirms, contradicts, neither affirms nor contradicts).
4. In what three modes is heat transported? _____, _____, _____.
5. Heating of earth by sun is an example of _____. Give another example.
6. Cooling of your house by leaving the door open at night is an example of _____. Give another example.
7. Heating of one side of a brick wall whose other side is already warmed is an example of _____. Give another example.
8. Heat supplied to a substance can change either the substance's _____ or its _____. When the _____ is changed, we call the heat _____; when the _____ is changed, we call the heat _____.
9. By how much will 20 feet of copper expand when heated from 60 F to 180 F?
10. To what temperature C must air in an enclosed vessel be heated to reach a pressure of 2 atmospheres?
11. If 1 kg ice at 0 C is added to 5 kg water at 50 C, what will happen?

1. If the pressure on a sample of (ideal) gas doubles, and the temperature stays the same, what should happen?
2. Describe at least three different uses for natural (heat-induced) convection of air or water or other fluids.
3. By doubling the surface area of a radiator used to heat a room, what improvement in heat delivery is made possible?
4. Why does unmixed water in a tank "stratify", with hottest water on top?(Trace the reasoning as carefully as you can.)
5. The primary source of heat on earth is _____ from the sun. If the sun's absolute surface temperature were to double, by how much would energy received on earth increase?
6. Describe (and attempt to rank in order of significance) the separate ways in which heat is lost from an outdoor uncovered swimming pool.
7. Ice at -40°C is to be melted and warmed to $+20^{\circ}\text{C}$ by being put into contact with a suitable amount of hot material which starts at $+50^{\circ}\text{C}$. This material may be chosen any one of several substances. Rank the following substances in increasing order of amount (mass) needed to do the job:
aluminum copper gold iron silver water
8. How much water will be needed as the material chosen in 7?
9. One kg of aluminum is to be heated from 20°C to 620°C , using electric resistance heating obtained via magical 100% conversion efficiency from water falling 100 meters. How much water will be needed?
10. A certain square foot of wall of a house in a region with 6000 annual heating degree days has overall resistance $R-1$. If its resistance is increased to $R-5$, how many btu heat loss are saved annually?
11. If in 10 heat costs \$.50 per therm ($=100,000$ btu) how much money will be saved over 30 years?
12. How do the figures in 10 and 11 change if wall starts at $R-16$ and is increased to $R-20$?
13. How do the savings in 10 and 11 compare with leaving the wall as is, but replacing electric resistance heat with heating from a heat pump of $\text{COP} = 3$?

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

Enrgy

155

*Course abbrev.

*Course number

Check ONE: ☒ NEW COURSE PROPOSAL: complete ALL items below.
☐ SYLLABUS UPDATE: complete only items marked with asterisk (*).
☐ REVISION: specify change _____

*COURSE TITLE: Energy Updating Seminars

STUDENT CLASS HOURS: 11-55
lect. lect/ lab shop clin. other syst.
lab.

1-5 100 Variable
Credits Instructor Capacity (est.) FTEF fraction Fee HEGIS code
contact hrs.

PREREQUISITE: None

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer ☐ occupational preparatory ☐ community service
☐ academic basic ☒ occupational supplementary
☐ academic general ☐ occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

Energy Management personnel and students in energy or related programs.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution ☐ ☐ AAS electives ☐ ☐ AAS electives ☒ ☐
(transfer only) yes no (transfer only) yes no (15 credit yes no
block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ ☒
yes no

CATALOG DESCRIPTION:

Updating energy seminars would contain information on current issues or problems facing energy consumption, conservation and/or renewable energies and to supplement existing energy courses. Possible topics might include: new types of energy control devices, energy "fairs", consumer awareness of energy conservation measures, workshops on installation techniques, etc.

*COURSE OBJECTIVES (standards against which student performance will be evaluated):

To offer updating seminars that are proven to be current topics of concern and/or hands-on experiences not presently incorporated into the existing program.

*METHODS OF INSTRUCTION: (includes also special requirements for materials, space, support)

Contractual arrangement with instructors or facilitators through the seminar office.

*EXAMINATIONS (methods of evaluating student attainment of objectives):

Attendance.

*GRADING:

Satisfactor and Unsatisfactory only!

*DETAILED COURSE OUTLINE:

Individual seminar outlines will be submitted prior to their offering.

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

	<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1.	_____	Course proposal form submitted to the office of the associate dean of instruction	_____
2.	_____	Page one completed.	
3.	_____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4.	_____	Reviewed by director of learning center	_____ (DLR)
5.	_____	Reviewed by Faculty-Administration Council.	
6.	_____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7.	_____	Course proposal form filed in temporary location.	
8.	_____	Pages two and three completed (prior to the end of the quarter in which taught).	
9.	_____	Page four completed.	
10.	_____	Course proposal form filed in permanent location.	

COURSE PROPOSAL FORM

Check ONE: (X) NEW COURSE PROPOSAL: complete ALL items below.
() SYLLABUS UPDATE: complete only items marked with asterisk (*).
() REVISION: specify change

STUDENT CLASS HOURS:		<u>55</u> lect.	lect/ lab.	lab	shop	clin.	other	syst.
5	5		35		.333			
Credits	Instructor contact hrs.	Capacity (est.)	FTEF fraction	Fee	HEGIS code			

() academic transfer () occupational preparatory () community service
() academic basic (X) occupational supplementary
() academic general () occupational "useful"

AAS distribution	() ()	AAS electives	() ()	AAS electives	(X) ()
(transfer only)	yes no	(transfer only)	yes no	(15 credit block)	yes no

This course is intended to cover energy use in residential and light commercial buildings. Building shell, mechanical, electrical -- and human -- energy systems will be studied. Students will learn intensive and extensive analysis of building heat losses and gains, and economic analysis of conservation alternatives including Life cycle costing, and role of proper maintenance in reducing energy use. Laboratory sessions will consist of energy audits of local buildings.

***COURSE OBJECTIVES (standards against which student performance will be evaluated):**

1. Principal energy uses in and on account of buildings, and of major opportunities for cost-effective energy conservation through use of appropriate design and materials, controls and maintenance, efficient energy-using equipment, well-considered scheduling and location of uses.
2. Components and importance of total energy management of buildings, with special attention to the need for building owners and users to be involved in and committed to a long-range energy management plan.
3. The components and importance of an energy audit, as a tool in total energy management. By the end of the course, students will know how to conduct all key phases of an audit.
4. Be able to solicit appropriate past and present data on building energy performance, and be able to develop from these data a preliminary statement on existing energy-use patterns. Students will be able to conduct an on-site inspection of building conditions, in order to evaluate effects of possible conservation measures. Students will then be able to recommend cost-effective changes in building operation. Students will be able to develop an energy management plan for building users, and to involve and instruct the users in developing and implementing the plan.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

Instruction methods will include: lectures, discussion, homework, at least one group audit of a residence and at least one of a commercial or institutional building. Each student will further be required to audit at least one new residence, one old frame residence, and one existing masonry residence; and do at least one full audit of a commercial or institutional building.

***EXAMINATIONS (methods of evaluating student attainment of objectives):**

Examinations for evaluating student attainment of objectives will comprise a midterm and a final, and occasional brief quizzes.

***GRADING:**

Grading will be based on student participation, performance on examinations, and--to a large extent--achievement on the required energy audits.

course standards:

*DETAILED COURSE OUTLINE:

TEXTS: Instructions for Energy Auditors, vols. 1 and 2, USD0E (CS/0041/13)
Energy and How to Conserve It, Ken Cooper, ECON, Vancouver BC.
To the Bank, or Up the Chimney?, HUD
These will be supplemented by various handouts.

1. Introduction

Basics of heat and comfort -- as in ENRGY 110

Total energy management, ingredients of energy management plan, role and phases of audit -- collect and analyze data, inspect on-site, recommend cost-effective alternatives, follow-up. Development of plan. Importance of user habit, involvement.

2. Effective first steps in energy management.

Establishing on-site responsibility. Collecting and analyzing data. Basics on importance of equipment and controls maintenance, scheduling, and other low- or no-cost conservation measures.

FIRST GROUP AUDIT

3. Building envelope.

Heat loss and gain: qualitative. Basic conservation measures. Introduction to quantitative treatment. Introduction to economics..

SECOND GROUP AUDIT

4. Lighting.

Concepts of lighting use and effectiveness and cost. Effects of lighting levels, placements, equipment. Basic conservation measures.

FIRST INDIVIDUAL AUDIT

5. Active heating in residences.

Sizing to account for building loss, internal and solar gains, etc.

All common systems considered, including heating of water for service and pools.

MIDTERM

SECOND INDIVIDUAL AUDIT.

6.-7. HVAC (heating, ventilation, air-conditioning) in buildings.

All systems, including motors and appliances.

THIRD AND FOURTH INDIVIDUAL AUDITS.

8. Review and details of heat loss calculations.

FIFTH INDIVIDUAL AUDIT.

9. Economics: review and details of calculations.

SIXTH INDIVIDUAL AUDIT

10. Building performance standards. Auditing opportunities.

Energy use index. Introduction to standards. Employment opportunities.

Overall review of course.

11. FINAL

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1. _____	Course proposal form submitted to the office of the associate dean of instruction	_____
2. _____	Page one completed.	
3. _____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4. _____	Reviewed by director of learning center	_____ (DLR)
5. _____	Reviewed by Faculty-Administration Council.	
6. _____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7. _____	Course proposal form filed in temporary location.	
8. _____	Pages two and three completed (prior to the end of the quarter in which taught).	
9. _____	Page four completed.	
10. _____	Course proposal form filed in permanent location.	

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TEACHING METHODOLOGY

ENERGY 210 - ENERGY AUDITING/CALCULATIONS

Intro. self, go over outline, EMT program description. Have everyone introduce themselves, describe their interest, expectations of course, status in EMT program. Explain procedures of course and scheduling.

Intro. Recall basics of heat, comfort. Temp., humidity, ventilation requirements, What are they? Are there others?

Prevent heat loss in buildings--basic approach of energy-use control in small building - namely residences.

Next week will audit residence. Assignment: develop an appropriate form which will tell us what we should know.

Concepts underlying energy audits:
energy management

Health care and medical programs--models for "energy fitness" "energy waste prevention". What do/can these programs consist of? Class generates list. A plan for "energy management" of a building should at least consider the ingredients in a person's "health management".

On list should be at least:

- med. history
- records
- professionals--physicians, etc.
- examination
- check-ups, follow-ups
- reports
- medicines
- diagnoses
- total treatment plan or symptom alleviation
- evaluations/criteria of success, disease
- "Patient" habits, involvement, psychology.

What do these correspond to in energy management?

"Audit" = ? Answer varies.

Various people have various approaches, comprehensive or adhoc, to their own health and fitness planning and action. Similarly with building owners and energy. "Audit" represents something like a medical examination--which may or may not be part of a good plan, and may or may not include various plan ingredients. In this course, we treat "audit" something like the first exam. when one has decided on a "family doctor". Criteria of fitness annual energy index (AEI) or energy use index (EUI)

Elements of a residential audit--Class generated list. Will use instructor's form to work on residential audits.

Basic idea of residential audit: energy loss = heat loss, via conduction and infiltration (air change)

Which aspects of energy use are thereby ignored? Answers: solar and people and appliance and lights heat gain; cooling energy; lighting and appliance energy; life-style; transport; etc.

Details on how we meet and proceed for first group audit (residence)

General energy management and audit

First steps.

Establish on-site responsibility as auditor (or audit supervisor)

Who are you working for? as boss? as client? as client's rep on-site?

Collect historical energy conservation data.

If inadequate, establish a data gathering, reporting system for future.

Be sure you have written records which identify basics about the building and those responsible for it.

Basic or first kinds of recommendations - these will suggest what to be looking for first: Equipment controls, maintenance, uses scheduling, low or no-cost options. Have class note examples.

Review procedures in group audit
Building envelope

Heat loss, gain. See residential audit forms

Heat loss by conduction, infiltration, otherwise (lights, people, appliances, sun...) insulation, caulking etc. as recommended procedures.

Use of heat-loss calculations (audit forms)

Economic analysis of possible conservation measures:

1. Establish an investment time period and a budget.
2. List alternatives--including do-nothing status quo.
3. Compared with status quo or some other standard, list each alternative's costs/benefits within time period. How to calculate future costs/benefits? (Discount to present--explain possibilities and difficulties, including inflation, taxes, client's investment alternatives, etc.)
4. Decide net benefit of each alternative.
5. Recommend alternative with max. net benefit.

Assign computations using values on audit forms.

Other computations.

NOTE: ease of using per square foot-heat loss cost vs. remodel costs. Comparison of given alternative with do-nothing by using payback time. Warning: do-nothing always has more attractive payback time. Payback time is not really a good basis for decisions, it's merely a relatively easy to calculate value.

Critique group audits, prepare for individual residential audits, lighting.

What do we want to know about light and lighting in order to conserve energy?
Class discussion.

Energy use process:

controls			
Source and supply	Conversion and distribution	task	objective

In residential heating, what examples do we have?

In lighting we have

Electricity	lamps, rays	task at lit surface	task objective
-------------	-------------	---------------------	----------------

We want to save the energy supply and its costs. We can do this by: getting another source (natural light), using more efficient lamps (more light per watt), or better distribution, (more illumination per amount of light), or better task, task lighting, and design to meet objectives (reschedule tasks to daylight hours, more tasks to same place to shared lighting, etc., Delamp unneeded fixtures, be sure lamps are off when no one needs them, etc.

How do we measure amount of light? Amount of illumination? Other suitability of light (color rendition, in particular)?

Which tasks have which requirements--in code or in practice?

Define: candle, lumen, efficiency = # lumens/watt, foot-candle (and lux), color rendition index.

Be sure class gets practice in identifying types of fixtures, and is aware of improved means of distribution (light-colored matte finishes, open spaces, lamps close to task without being shadowed, inverse square law)

Review for mid-term, review individual residential audits.

Residential heating

Review of types of systems -- needed for system type i.d. in audit.

Source of energy? gas, oil, coal, wood, electricity, solar, etc.

How converted to heat? combustion, elec. resistance, direct heat pump, etc.

How distributed? from central "furnace", or room by room.

Form of heat delivery? warm air (convected), radiant surfaces (from water pipes or otherwise)

Other classificational questions, as suggested by class.

Conservation opportunities

- | | | |
|--------------|----|---|
| SOURCE | 1. | Can source be replaced by sun or other renewable? |
| CONVERSION | 2. | Can conversion be more efficient? Check furnace burner, or boiler. |
| & | | Can distribution be improved? Check duct insulation. Waste heat |
| DISTRIBUTION | | recovery - ceiling fans? |
| | 3. | Can night set-backs and other measures be used to control and operate |
| TASKS | | existing hardware more efficiently? Can rooms be closed off, or |
| & | | scheduling changes made? |
| CONTROL | | |

E 210 Weeks 6 & 7

Critique midterm, individual audits.

HVAC in buildings.

Differences between energy in residences and in (large) buildings.

Ask class to generate list. It should include:

- heat-loss not only major source of energy use
- Cooling load, from people and lights and machinery
- Ventilation requirements
- Usage and scheduling requirements

Review or survey of typical HVAC equipment:

- boilers,
- chillers
- pumps
- fans
- combined units--fan coil, etc.

HVAC system types (See WSEO Schools and Hospitals write-up)

Ask class to describe types, given their names

Ask class to "guess" conservation opportunities.

Motors, industrial requirements - sketchy survey.

Handouts: check list for commercial audits.

Assignment: 1. identify building, management, status of any energy mgt. efforts
Commercial 2. look at check list, and consider at least 3 items in each category
audits 3. recommendations

E 210 Week 8

Review, critique commercial audits.

Review heat loss calc - residential audit form

Any questions.

Review heat loss calculation. Typical residential example, res. audit forms

E 210 Week 9

Review, critique, questions on commercial audits

Economics: Review and details

Week 3

Details: methods of discounting

Review: net benefit

payback

internal rate of return

critique reliance of these concepts.

Look at benefit/cost assessment. Record "intangibles", too.

E 210 Week 10

Review, recap of commercial audit

Building codes - what kinds are there

Types of "energy" building codes.

Prescriptive - tell you what to do

Performance - tell you what must result

Prescriptive approach - somewhat in component efficiencies approach (ASHRAE 90-75)

Performance approach - in BEPTS (building energy performance stds.)

Combined: Seattle and Washington State Energy Codes permit either compliance pathway.

Auditing opportunities

Where?

Employers?

Ask class to make list. Be sure they include utilities, refer to NECPA RCS types of audits and energy management programs.

Review (overall) of course.

Sample final.

SUPPLEMENTAL INSTRUCTIONAL MATERIALS

ENERGY 210 - ENERGY AUDITING/CALCULATIONS

ENERGY 210 ENERGY AUDITING/CALCULATIONS Edmonds Community College Spring 1980

Tu.Th. 7:30-9:15 Room 217 ~~Mountain Terrace Hall~~ ^{4x Woodward}

Instructor: Joe Weinstein -- reachable at Energy Value Inc., 325-6710.

Texts: Instructions for Energy Auditors, vols. 1 & 2, USDOE (CS/0041/12, CS/0041/13)
Energy and How to Conserve It, Ken Cooper, ECON, Vancouver BC.

In the Bank, or Up the Chimney? HUD.
These will be supplemented by various handouts.

This course is intended to cover energy use in residential and light commercial buildings. Building shell, mechanical, electrical -- and human -- energy systems will be studied. Students will learn intensive and extensive analysis of building heat losses and gains, and economic analysis of conservation alternatives including life cycle costing, and role of proper maintenance in reducing energy use. Laboratory sessions will consist of energy audits of local buildings.

Students will become aware of principal energy uses in and on account of buildings, and of major opportunities for cost-effective energy conservation through use of appropriate design and materials, controls and maintenance, efficient equipment, careful scheduling and siting. Students will become aware of components and importance of total energy management of buildings with emphasis on need for building users to be involved in a long-range management plan. Students will become familiar with the components and importance of an energy audit, as a tool in total energy management, and will learn how to conduct all key phases of an audit. These will include: solicitation of past and present building energy performance data, development of preliminary statement on energy use patterns, on-site inspection of building conditions, evaluation of effects of possible conservation measures, recommendation of cost-effective operations changes, development of energy management plan, instruction of users in developing and implementing the plan.

Instruction methods will include: lectures, discussion, homework, at least one group audit of a residence and at least one of a commercial or institutional building. Each student will further be required to audit at least one new residence, one old frame residence, and one existing masonry residence; and do at least one full audit of a commercial or institutional building. Grading will be based on quizzes and in-class 20%, midterm 15%, final 30%, audits 35%.

OUTLINE

Week	Tu. date	Topic
1	4/1	<u>Introduction</u> . Basics of heat and comfort. Total energy management. Ingredients of energy management plan, role and phases of audit -- collect and analyze data, inspect site, recommend cost-effective alternatives, follow-up, develop plan. Importance of user habit, involvement.
2	4/8	<u>Effective first steps in energy management</u> . Establish on-site responsibility. Collect, analyze data. Importance and basics of equipment and controls maintenance, scheduling, other low- or no-cost conservation. FIRST GROUP AUDIT.
3	4/15	<u>Building envelope</u> . Heat loss and gain: qualitative. Basic conservation. Intro. to quantitative treatment. Intro. to economics. SECOND GROUP AUDIT.
4	4/22	<u>Lighting</u> . Concepts of lighting use and effectiveness and cost. Effects of lighting levels, siting, equipment. Basic measures. FIRST INDIV. RES. AUDIT.
5	4/29	<u>Active heating in residences</u> . Sizing to meet building loss and gains. Common space and water heating systems (domestic and pools). MIDTERM. 2d RES. AUDIT.
6	5/6	<u>HVAC</u> (Heating, ventilation, air-conditioning) in buildings. All systems, incl.
7	5/13	motors and appliances. LAST RES. AUDIT. FIRST PHASE, COMMERCIAL AUDIT.
8	5/20	<u>Review and details of heat loss calcs</u> . 2d PHASE, COMMERCIAL AUDIT.
9	5/27	<u>Economics</u> : review and details. LAST PHASE, COMMERCIAL AUDIT.
10	6/3	<u>Building performance standards</u> . Auditing opportunities. Overall review.
11	6/10	FINAL.

ENERGY CONSERVATION: A SYSTEMATIC METHOD FOR FINDING ALTERNATIVES,
ILLUSTRATED WITH EXAMPLES IN HEATING AND LIGHTING.

The vast literature on energy and its conservation tends to emphasize facts and prescriptions, but scarcely helps show us how we may systematically study an energy-use process in order to generate our own list of feasible conservation options. We do need such help. Many opportunities for energy conservation are unduly overlooked, and guidance in finding them would be useful.

Described here is a simple "network model" which can be used to analyze many energy-use processes. Each part in the model corresponds to a kind of conservation opportunity. The model is intended to be both simple enough and complex enough so that the resulting list of energy conservation opportunities is both understandable and reasonably complete.

We shall see how the model "fits" a process -- home heating -- whose conservation opportunities are reasonably familiar. Having thus learned how to work with the model, we then use it to explore conservation concepts and alternatives in a field which has remained all too needlessly mysterious for most energy conservation workers: lighting.

Energy-use processes.

Energy use is not an end in itself but rather is a means to accomplishing a task or tasks. The task is itself directed toward some objective or goal. For example, air is heated (the task) in the living room of a house in order to meet standards of comfort for the residents. Water is heated on a cooktop in order that people may sip tea; etc.

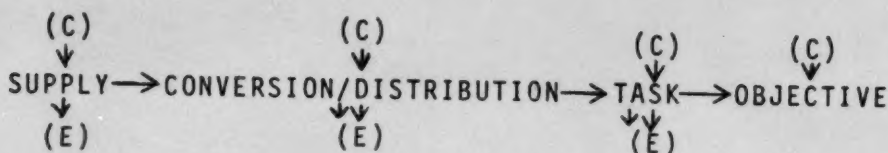
Energy is rarely used in the form in which it is supplied to the premises. Delivery may be in the form of a substance -- oil or natural gas, say -- or as a form of energy -- electric current, say. Some device or combination of devices -- a furnace and blower, or an electric resistance coil -- converts the supplied form to the used form, and delivers the latter for use.

An energy-use process thus consists of stages, each joined to the next by a "flow" of something which leads to or results from use of energy:

SUPPLY → CONVERSION/DISTRIBUTION → TASK → OBJECTIVE

Each of these stages or "nodes" might itself be broken into substages. For example, in heating a living-room, SUPPLY might divide into a storage tank plus a feeder pipe from the tank, CONVERSION/DISTRIBUTION might divide into conversion (furnace) plus distribution (ducts), TASK might divide into air-heating plus skin-heating, and OBJECTIVE might divide into agreeable sensations for skin heat-sensors plus resulting self-contentment.

From each node (other than the right-hand-most) there is not only a rightward flow but also added flows-- diagrammed as downward -- that represents "waste" or "unused" flows to the "environment" (both of the "stuff" flowing to the node and of the stuff flowing from the node). Also, for each stage -- diagrammed as (C) above the stage -- there is what we call its controller: the combination of automatic and humanly-controlled features which enables the stage to work differently at different times or in different situations. The hardware of a controller can be as simple as a single switch, or as complex as an entire computer system. In the latter case, the controller may itself be considered to have a controller of its own (programmers, terminals, etc.). (See diagram, following:



In the diagram each (E) stands for the environment of the stage just above it. For simplicity, each flow that starts from some node is deemed to be "controlled" by the controller for that node.

Those features of an energy-use process which are not subject to variation or "control" over time may, for convenience, be ascribed to prior "design".

Conservation opportunities.

Each downward flow stands for a possible "waste" or "loss" to the environment, or for possible inadequacies in control. Accordingly, each downward flow represents a conservation opportunity.

A control flow, in particular, may represent a source of waste insofar as the controller falls short of the ideal. The ideal controller should be accessible to beneficial human intervention which enables the process to save energy in particular situations, yet should somehow resist non-beneficial intervention which would waste energy. (One practical approach toward this ideal is that of a timed light switch requiring positive reset every so often in order to maintain energy flow.)

To understand remaining conservation opportunities, we must define what the goal of "conservation" is, in terms of our model: it is to achieve the OBJECTIVE by use of as little as possible of the sources of SUPPLY, insofar as those sources are judged as "conservands"-- sources which should be conserved.

In terms of this goal, each of the main stages -- in itself and in the flows from it -- gives rise to a distinct kind of conservation opportunity:

1. SUPPLY. Replace the source by another source which is less of a conservand. For example, replace heating oil by solar heating.
2. CONVERSION/DISTRIBUTION. This stage is the means by which useful energy is furnished, and improvements here represent efficiency of means. They include equipping the furnace (conversion equipment) with a flame-retention burner; insulating ducts (distribution); and installing (additional conversion/distribution) equipment to reclaim waste heat.
3. TASK. This stage represents the end-use of energy. The issue is now end-use effectiveness: how effective, in nature and scope, are the end uses in promoting the objective? Replace tasks, wherever possible, by similar ones (or others) which use less energy. Here, measures for end-use effectiveness include: insulate house so that task of making up for lost heat is lessened; see that heat is not on when no one is present; encourage wearing of sweaters on cold days.
4. OBJECTIVE. The issue is now definition of objective. Does comfort really mean perceiving air temperature as 65°F, or can the concept permit redefining the required minimum to be 62°F by day and 55°F by night?

Lighting: process and conservation opportunities.

We can now easily and usefully describe lighting as an energy-use process with stages as analysed above. Electricity is the source of SUPPLY. Light is the useful result to which this electricity undergoes CONVERSION in the luminaires (or "globes") and direct line-of-sight radiation plus possible reflection is the mechanism of DISTRIBUTION. The intended TASK is to illuminate certain surfaces to certain levels of illumination, in order that standards for comfort and productivity in certain work-tasks be achieved -- the OBJECTIVE. (The objective also requires that the light achieve certain standards of faithfulness in color rendition.)

Different "things" thus "flow" at different stages in this process. In order to measure conservation achievement, we must at least have an idea of these things.

During the supply stage we are concerned with electric energy, measured and billed per kWh, kilowatt-hour.

During the conversion/distribution stage, we seek to measure "amount of light". The rate at which a light source produces "usable light" is measured in a unit called a "candle" (in English) or "candela" (internationally). This rate of "light production" is not strictly proportional to the electric power used, but rather depends considerably on characteristics of the kind of luminaire. The "lumen" is a unit about 8% of a candle (or, more exactly, 4π lumens = 1 candle). It represents the amount of light which a 1-candle source, radiating equally in all directions, will send to one square foot at a distance of 1 foot, or to one square meter at a distance of one meter, or indeed to one square unit at a distance of one linear unit (whatever the unit). One lumen per square meter represents illumination from light (that is, light per unit area) falling one meter away from a 1-candle source. (This lighting level is called 1 lux.) One lumen per square foot represents illumination of light falling one foot away from a 1-candle source, and is called 1 foot-candle (1 fc.).

During the task stage we seek to illuminate given surfaces to given illumination levels, expressed in foot-candles. These levels are intended to meet code standards (or other prescribed objectives for illumination levels).

There are many conservation opportunities which stem from improved and more flexible and responsive controllers in lighting: controllers which can vary lighting according to place, time, requirements of tasks and zones. (One must be careful about a few things: that "dimmers" really save power rather than diverting power from producing light to producing heat.)

Source replacement -- in particular, use of natural lighting -- is an obvious yet exciting and developing area for lighting conservation. When possible, natural lighting should come from different directions at right angles to one another, to prevent silhouette effects.

Efficiency of means. Conversion: Here the goal is to use fixtures and luminaires which give maximum light (measured in lumens) per given electrical input (measured in watts). Efficiency of a luminaire is thus measured by the ratio of lumens to watts. This efficiency depends mainly on the type of luminaire: for incandescent ("standard") luminaires it is about 15-20, for fluorescent about 60-80, for metal halide up to 100, for high and low pressure sodium about 120 or even 150. (A theoretical limit exists for any conceivable luminaire: 685.)

Unfortunately, the more efficient fixtures and luminaires tend not only to be more expensive but also tend to have poorer color rendition. There has been defined a "color rendition index", according to which natural light has index 100 -- maximum possible. Incandescent luminaires have index about 95, fluorescents from about 60 to 80. The most efficient fixtures of all, low-pressure sodium lamps, have index very nearly zero: their light permits almost no color distinction. Choosing good fixtures and luminaires thus requires attention to finances and color rendition as well as to efficiency. Furthermore, contrary to implications of advertising by luminaire and fixture manufacturers, conservation in lighting is far from merely a matter of efficient conversion.

Efficiency of means. Distribution: Tremendous conservation opportunities result from taking steps to improve distribution of available light. First, locate the fixtures as near as possible to the end-use tasks: illumination level goes down as the square of the distance. Second, open up the space, if possible, to take advantage of natural light (and distant artificial light) penetration. Third, use light colors on as many surfaces as possible, to reflect light. But use a matte (diffusing, rather than glossy) finish on as many surfaces as possible, to prevent glare. (The eye finds it difficult to see in areas of high differences of illumination intensity, such as occurs with glare spots. For the same reason, in placing fixtures near to tasks, nevertheless try to avoid creation of shadows near work surfaces.) In order to permit use of efficient luminaires with poor color rendition, ~~color surfaces with those colors~~ which best respond to the luminaires, and consider mixing in some less efficient luminaires with better color rendition

End-use effectiveness. Try to group jobs requiring lighting together in time and space. See that lights are not on when no one is using them. See that zones by which light is controlled are not larger than the separate job areas. Provide extra individual fixtures precisely where needed for extra illumination ("task lighting"). "Delamp" unneeded fixtures.

Definition of objective. Note that for most tasks little is gained by increasing illumination over 25 foot-candles. Be sure illumination objectives do not needlessly exceed code requirements.

Be very careful before embracing the objective of "heating via lighting". Direct heaters may do the job more efficiently -- and not represent a cooling burden in the summer -- and even if the lighting system is a good source of wintertime heating, other energy measures, in particular draperies, are needed to ensure maximum effectiveness.

DISCUSSION OF HVAC SYSTEMS

Each HVAC system is of course unique and its particular characteristics can only be identified by inspection and measurement. It will, however, have many characteristics which are common to all systems of its generic group and it is the common characteristics which are discussed in this section.

The minimum information required to understand the present operation of a system and to provide a basis for deciding which modifications are likely to prove beneficial is tabulated below. Measurement should be as nearly simultaneous as possible.

Air Flow Rates

- total outdoor air
- total return air
- total supply air
- trunk ducts
- terminal units
- air cooled condenser

Water Flow Rates

- through boilers
- through chillers
- cooling towers
- heat exchangers
- coils and terminal units

Temperatures

- outdoor air DB & WB
- return air DB & WB
- mixed air entering coils, DB & WB
- supply air leaving coils, DB & WB
- hot deck
- cold deck
- air at terminals
- conditioned areas DB & WB (typical for each functional use)
- boiler supply & return
- chiller supply and return
- condenser supply and return
- heat exchanger supply and return
- coil supply and return

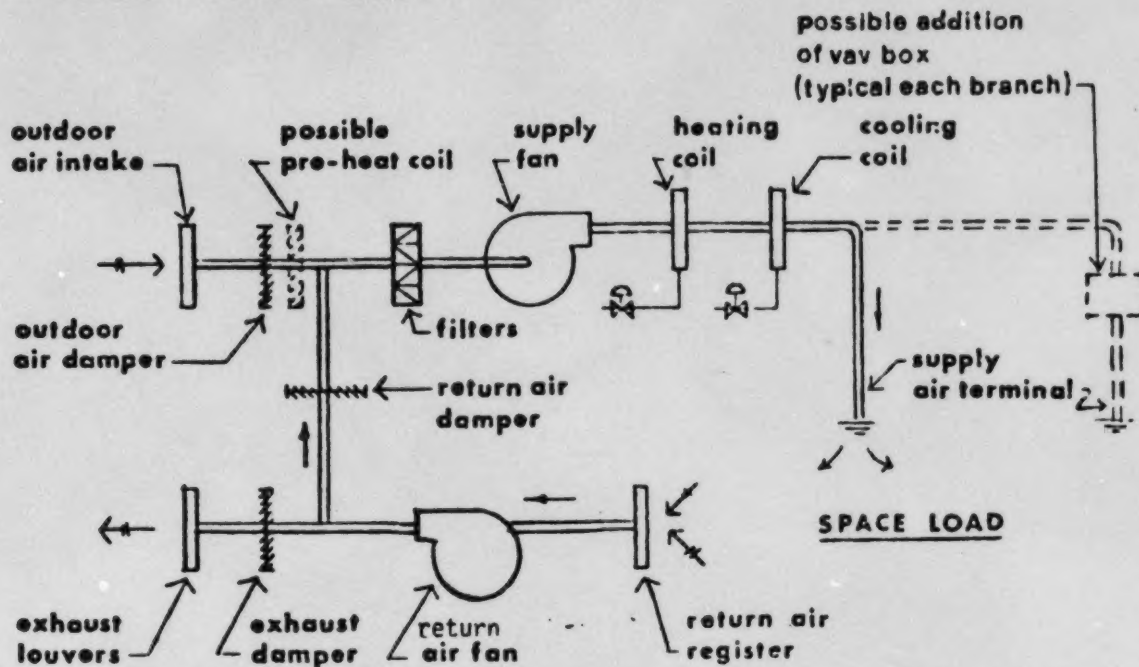
Refrigerant Temperatures - hot gas line suction line

Energy conservation must be approached in a systematic manner rather than considering individual items out of context. Systems do not operate in isolation but depend on and react with other systems. It is important to recognize this interaction of systems as modification to one will cause a reaction in another which may be either beneficial or counter-productive.

Buildings frequently use a combination of system types to meet the differing requirements in interior and perimeter zones. It is common practice, for instance

to use a VAV system for interior spaces and multi-zone system and/or radiation for perimeter spaces. There is an interface point between the interior and perimeter zones where mixing and interaction between the two different systems takes place. In cool weather, cold supply air from the interior zone can spill into the perimeter zone resulting in overcooling and shift to a heating mode of operation and in hunting with both systems cooling and overheating. To avoid this situation, increase the supply air temperature for interior zones in cold weather.

SINGLE DUCT, SINGLE ZONE SYSTEMS



representative single duct system

These systems are the simplest and probably the most commonly used. They can comprise just a single supply system with air intake filters, supply fan and heating coil or can become more complex with the addition of a return air duct, return air fan, cooling coil, and various controls to optimize their performance. Basically, the system supplies air at a pre-determined temperature to one zone or the entire building, the quantity of heating or cooling being controlled either by modulating the supply air temperature or by turning the system on and off.

The energy output of a single duct system to meet a space load is determined by the volume/temperature differential relationship, i.e., to maintain a space temperature of 65°F, the heating load could be met by a system supplying 10,000 cfm at 105°F, or 6,000 cfm at 125°F.

To conserve energy in single zone, single duct systems, determine from measurements the system output and the building load. In the heating mode, if the system maximum output exceeds design building load, first reduce the volume of system air as this will show the greatest energy saving, i.e., 90% of the original fan volume requires only 65% of the original fan HP. Next reduce the supply temperature; this will not conserve as much energy as reduced volume flow.

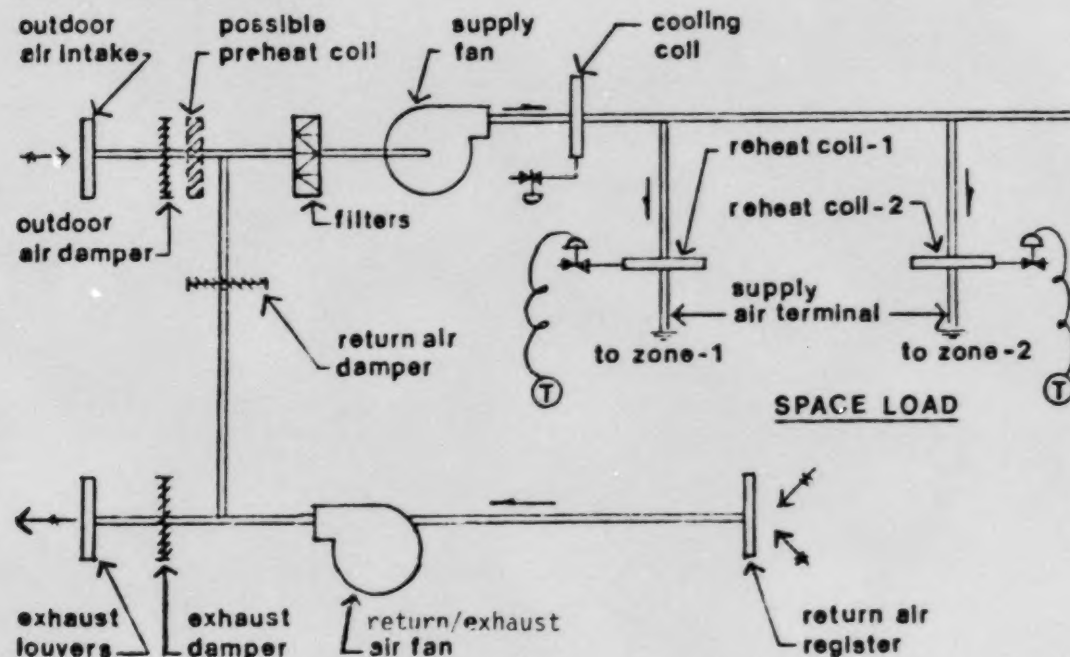
In the cooling mode, if the system output exceeds the design building load, the saving by reduced air flow must be equated with the saving by increased air temperature as increased COP of the refrigeration equipment may yield savings which exceed the fan power losses.

Install controls on the heating and cooling coils to modulate the supply air temperature. Allow a 8 - 10° "Dead Zone" between heating and cooling to prevent simultaneous heating and cooling and rapid cycling. If possible, use an economizer cycle wherever the total heat of the outdoor air is favorable during occupied periods; the sensible temperature is favorable in unoccupied periods; and the size of the system makes the installation economic.

The economizer cycle can be a simple arrangement of dampers controlled by outdoor and return air DB temperature or can be a more complex system based on the total heat or enthalpy of the outdoor air, return air, and the desired enthalpy of the supply air.

Single zone single duct systems can be readily converted to VAV by adding control boxes on each branch and substituting outlets with VAV type. Fan volume should preferably be controlled according to demand either by installing inlet guide vanes or by installing a variable speed motor.

TERMINAL REHEAT SYSTEMS



representative terminal reheat system

Terminal reheat systems were developed to overcome the zoning deficiencies of single duct systems and basically comprise a single duct, single zone system with individual heating coils in each branch duct to zones of similar loads. Reheat systems were also developed to give closer control of relative humidity in selected spaces.

Terminal reheat allows each different zone to be individually controlled but wastes energy in the cooling season as all of the supply air must be cooled to a low enough temperature to meet most critical load zone but must be reheated for zones of lesser loads to avoid overcooling.

As with single duct systems, energy can be conserved by reducing the supply air volume. Many reheat systems are controlled at a fixed supply temperature of around 55°DB/55°WB. To conserve energy, fit controls to reschedule the supply air temperature upward according to demands of the zone with the greatest cooling load. If one zone has cooling loads grossly in excess of all others, the controlling thermostat should be located in that space.

The greatest quantity of energy can be saved by adding variable air volume boxes to each of the major branch ducts. Each VAV box should be controlled by a space thermostat located in its particular zone and its associated reheat coil should be provided with controls to prevent reheat until the VAV box has reduced the zone supply air volume to 50%.

In buildings where a reheat system supplies zones of different occupancy, add dampers and control valves to enable water to be shut off during unoccupied times.

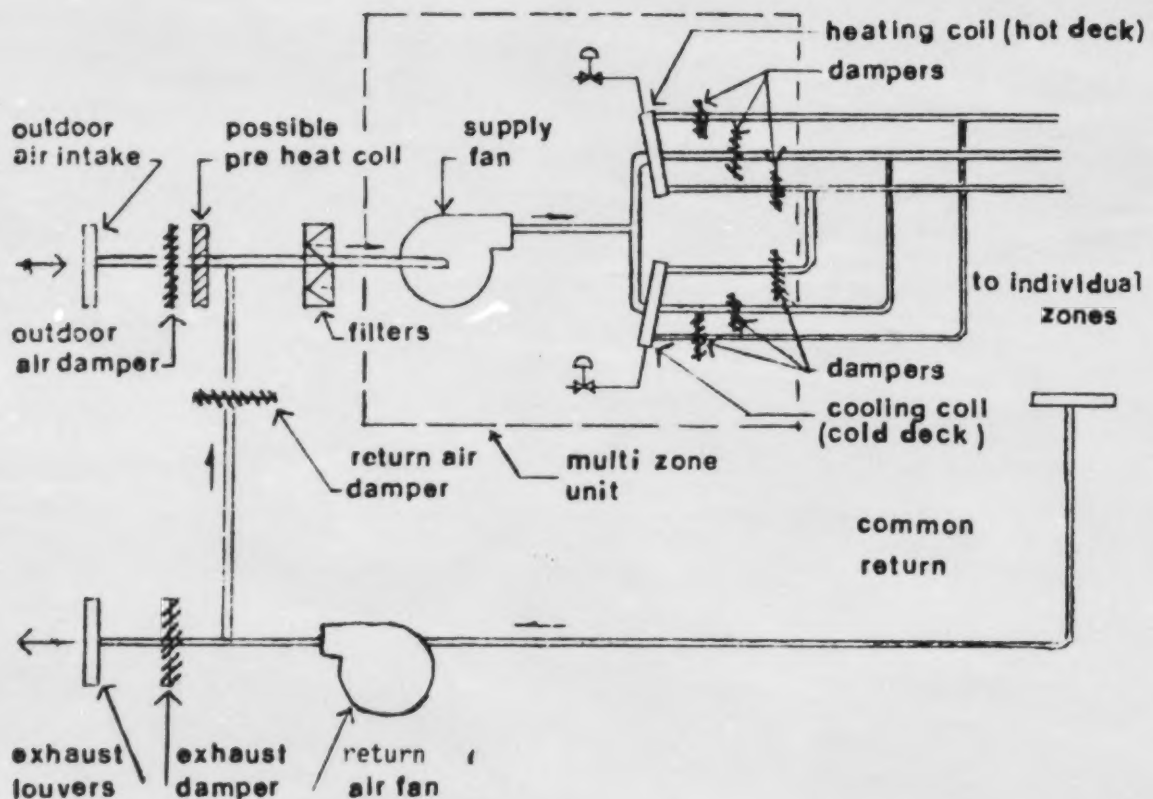
- Reduce the water flow and temperature of hot water to reheat coils.
- Use waste heat from condensate, incinerators, diesel or gas engines, or solar energy for reheat; but in all cases, raise the cold duct temperature to reduce refrigeration load.
- Modify controls to operate terminal reheat systems on a temperature demand cycle only. Caution: Control of humidity will be eliminated and zone control will be modified.
- Add or adjust controls to schedule supply air temperature according to the number of reheat coils in operation. If 20% of the coils are in operation, reset supply air temperatures to a higher level until the number of reheat coils falls to 10%.
- Install an interlock between the two valves to prevent simultaneous heating and cooling.

-If air conditioning is needed during unoccupied hours or in very lightly occupied areas, install controls to de-energize the reheat coils, raise the cold duct temperature and operate on demand cycle.

-Under an alteration or expansion program, install variable volume rather than terminal reheat or other systems.

-De-energize or shut off terminal reheat coils, raise the chilled water and supply air temperature of the central system and add re-cooling coils in ducts in areas where lower temperatures are needed.

MULTI-ZONE SYSTEMS



representative multi zone system

Most multi-zone units currently installed have a single heating coil serving the hot deck and single cooling coil serving cold deck. Each zone supply temperature is adjusted by mixing the required quantities of hot and cold air from these coils. With these types of units, the hot deck temperature must be sufficiently high to meet the heating demands of the coldest zone, and cold deck air must be sufficiently low to meet the demands of the hottest zone. All intermediate zones are supplied with a mixture of hot and cold air wasting energy in a similar manner to reheat systems.

New model multi-zone units are now available on the market which have individual heating and cooling coils for each zone supply duct and the supply air is heated or cooled only to that degree required to meet the zone load. These new types of units use far less energy than units with common coils and where renovations are contemplated or the existing multi-zone unit is at or near the end of its useful life, replacement should be considered, using a multi-zone unit with individual zone coils.

Analyze multi-zone systems carefully and treat each zone as a single zone system and adjust air volumes and temperature accordingly.

Hot deck and cold deck dampers are often of poor quality and allow considerable leakage even where fully closed. To conserve energy, check these dampers and modify to avoid any leakage.

Install controls or adjust existing controls to give the minimum hot deck temperature and maximum cold deck temperature consistent with the loads of critical zones.

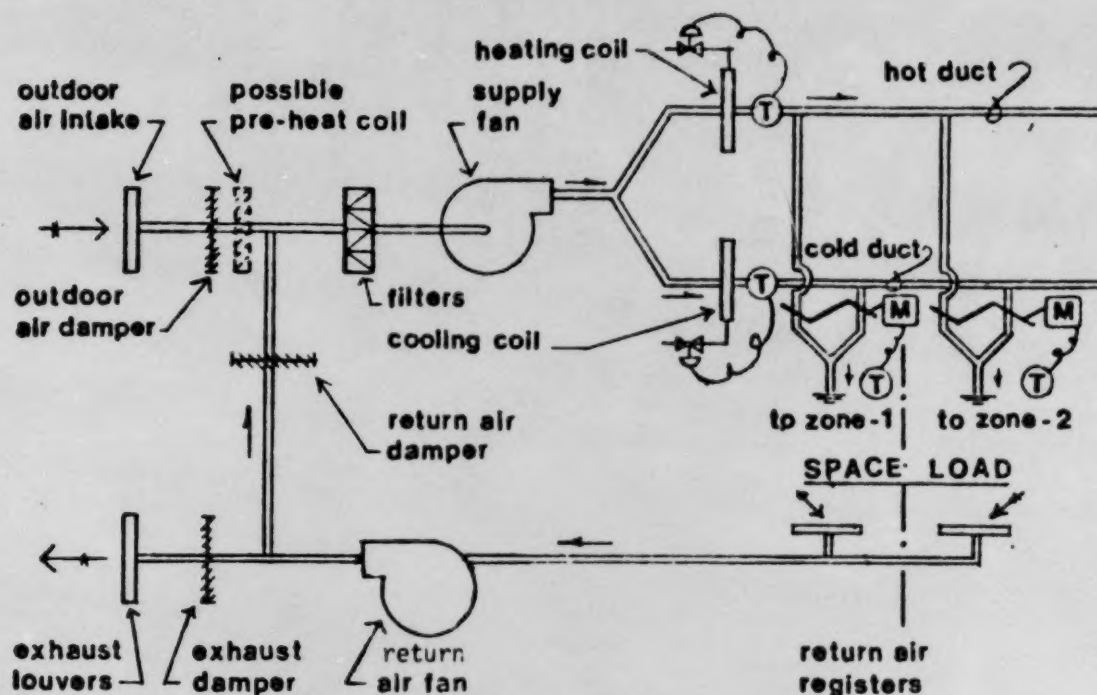
Where a multi-zone unit serves interior zones that require cooling all of the summer and most of the winter, energy can be conserved by converting to VAV reheat. To achieve this, blank off the hot deck and add low pressure VAV dump boxes with new reheat coils in the branch duct after the VAV box. This system works well in conjunction with an economizer cycle and reheat energy is minimized. Careful analysis, however, is required of the existing system and the zone requirements to make the correct selection of equipment.

Arrange the controls so that when all hot duct dampers are partially closed, the hot deck temperatures will progressively reduce until one or more zone dampers is fully opened and, when all of the cold duct dampers are partially closed, the cold duct temperature will progressively increase until one or more of the zone dampers is fully opened.

- Install controls to shut off the fan and all heating control valves during unoccupied periods in the cooling season and shut off the cooling valve during unoccupied periods in the heating season.

- Convert system entirely or in part to variable volume by adding terminal units and pressure bypass and/or add fan coil units in specific areas requiring constant air volume.

DUAL DUCT LOW VELOCITY SYSTEM

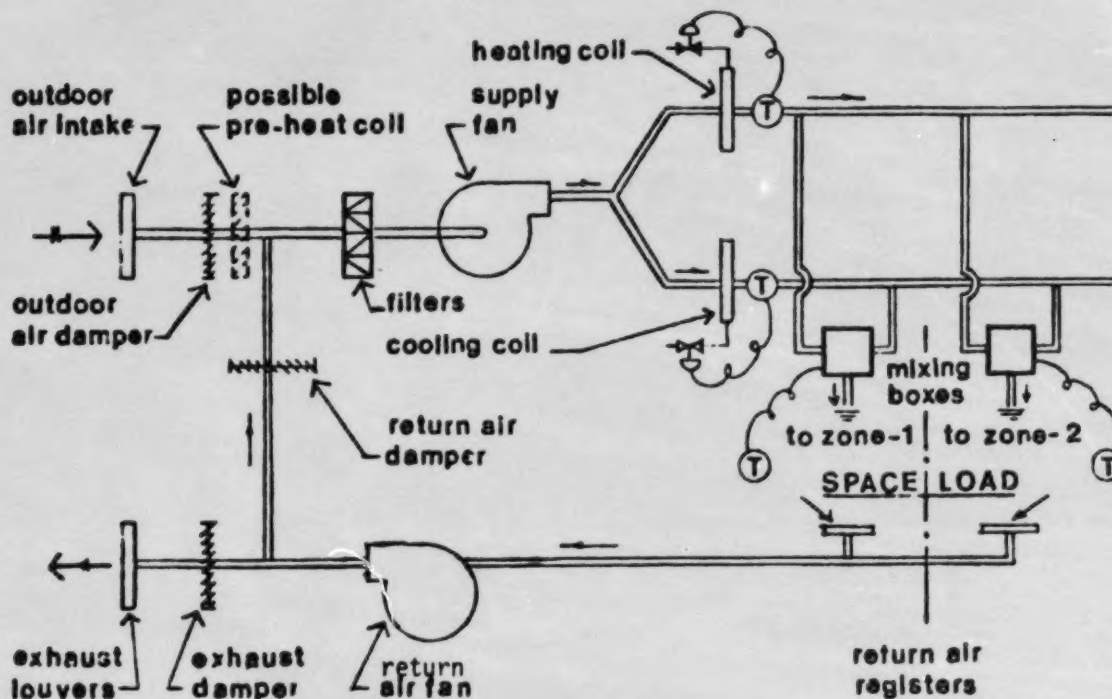


representative dual duct low velocity system

Dual duct low velocity systems supply hot and cold air in individual ducts to the various zones of the building which are supplied with a mixture of hot and cold air to maintain the desired zone conditions. Control of mixing is normally achieved by automatic dampers in the branch ducts; the damper being positioned according to the dictates of the space thermostat. Each duct should be analyzed as a single zone system to determine whether the air volume or its temperature set point can be advantageously changed to conserve energy. Reduce the temperature of the hot duct and increase the temperature of the cold duct to that point where the heating and cooling loads of the most critical zone can just be met.

Return air is a mixture of all zones and reflects the average building temperature. In some designs of central station equipment, it is possible to stratify the return air and the outdoor air by installing splitters so that the hottest air favors the hot deck and coldest air favors the cold deck. This will reduce both heating and cooling loads.

DUAL DUCT HIGH VELOCITY SYSTEMS



representative dual duct high velocity system

Dual duct high velocity systems operate in the same manner as low velocity systems with the exception that the supply fan runs at a high pressure and that each zone requires a mixing box with sound attenuation.

Considerable quantities of energy are required to operate the fan at high pressure and close analysis of pressure drops within the system should be made and fan pressure reduced to the minimum to operate the mixing boxes.

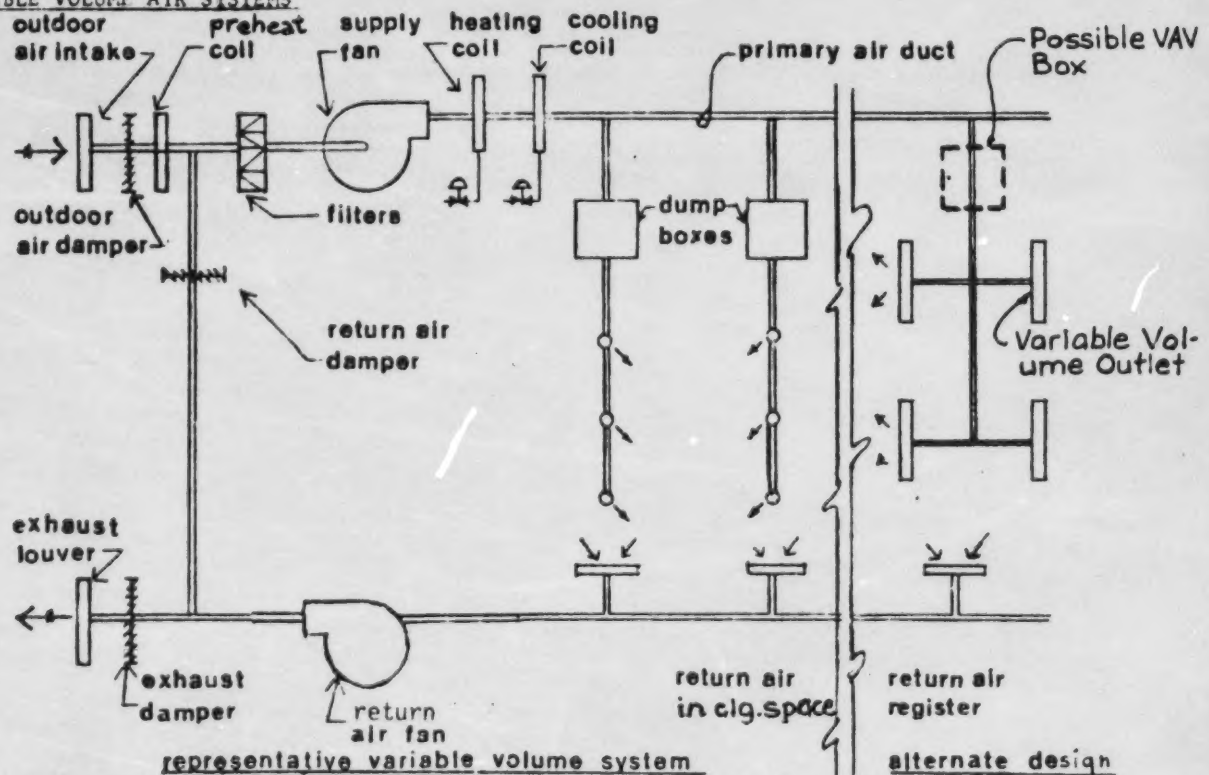
To reduce system pressure, replace existing high pressure mixing boxes with lower pressure types.

-In conditions when there is no cooling load, install controls to close off cold air duct; de-energize chillers and cold water pumps and operate as a single duct system; rescheduling the warmer air duct temperature according to heating loads only.

-Under conditions where there are no heating loads, install controls to close off the warm air ducts; shut off hot water, steam or electricity to the warm duct and operate the system with the cold duct air only; rescheduling supply air temperature according to cooling loads.

- Replace obsolete or defective mixing boxes to eliminate leakage of hot or cold air when the respective damper is closed.
- Provide volume control for the supply air fan and reduce capacity preferably by speed reduction when both the hot deck and cold deck air quantities can be reduced to meet peak loads. Reducing the heat loss and heat gain provides an opportunity to reduce the amount of air circulated.
- When there is more than one air handling unit in a dual air system, modify duct work if possible so that each unit supplies a separate zone to provide an opportunity to reduce hot and cold duct temperatures according to shifting loads.
- Change dual duct systems to variable volume systems when energy analysis to do so is favorable and the payback in energy saved is sufficiently attractive by adding VAV boxes and fan control.

VARIABLE VOLUME AIR SYSTEMS



VAV Systems are basically a modification of single zone, single duct systems to allow different conditions in multiple zones to be met by varying quantities of constant temperature air. The air quantity supplied to the zone can be modulated in two different ways:

Dump boxes installed in the zone supply duct modulate the amount of air through the outlets by bleeding off unused quantities of air and dumping into the ceiling

void and back into the return air system. This type of VAV system maintains constant fan volume and constant flow in all the trunk ducts and can waste energy by mixing the treated dump air with the return air. This system does, however, have practical advantages when used with direct expansion cooling coils since it maintains constant flow through the coils regardless of load, which is necessary to obtain correct operation of refrigerating equipment.

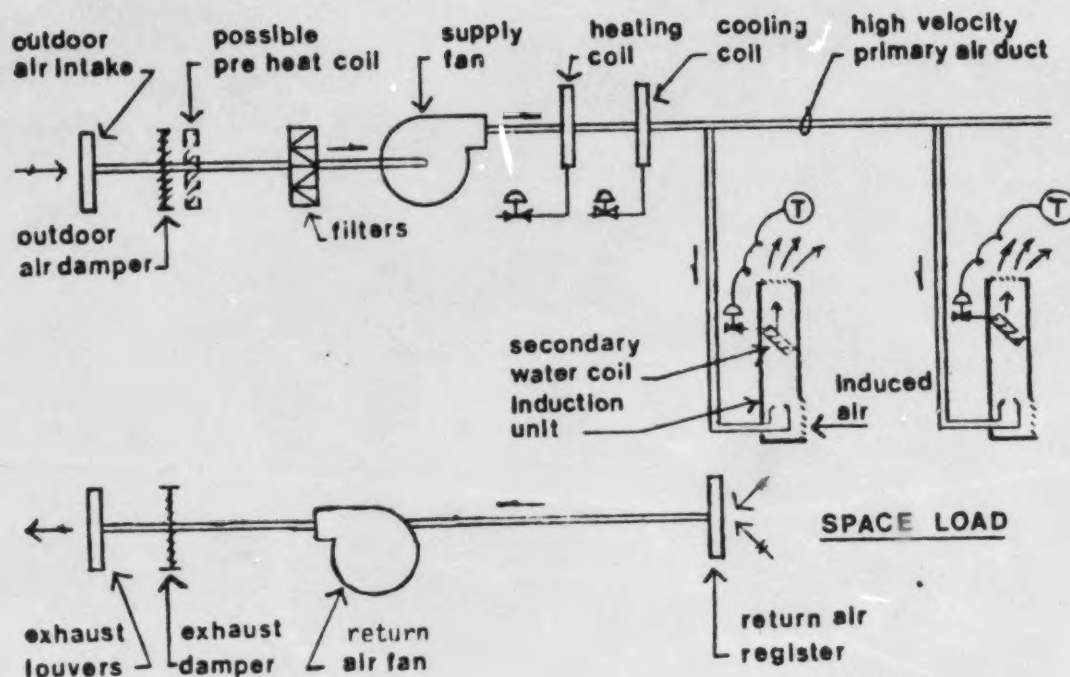
The second type of VAV system is where the air volume is controlled at the outlet by closing down dampers as the zone load decreases. This type of system does, in fact, vary the total supply volume handled by the fan by increasing the resistance to air flow under light load conditions.

To conserve energy, regulate the fan volume according to the demands of the system by a variable speed motor with SCR controller or by inlet guide vanes.

Provide a control to modify the fan speed up or down to maintain constant pressure in the supply duct. Reset the supply air temperature in accordance with zone loads.

- If not installed, provide either inlet vortex dampers or variable speed drive such as a multispeed motor or SCR control so that fan volume will be reduced when dampers begin to close until one or more VAV dampers is fully opened.
- Provide control to reschedule supply air temperature to a point where the damper of the variable air volume box serving the zone with the most extreme load is fully opened.
- Install control to reduce the hot water temperature and raise the chilled water temperature in accordance with shifting thermal demands.
- As with single duct variable volume systems with reheat, set control to delay reheat until cfm is reduced to minimum.
- Where possible, eliminate reheat coil and set the box to full close off.
- Variable volume with reheat systems should be operated and modified similarly to conditions described for terminal reheat.

INDUCTION SYSTEMS



representative induction unit system

Induction systems are commonly used for heating and cooling perimeter zones where large fluctuations of heating and cooling loads occur.

Primary air is either heated or cooled and supplied at high pressure to the induction units located within the conditioned space. Primary air is discharged from nozzles arranged to induce room air into the induction unit approximately 4 times the volume of the primary air. The induced air is cooled or heated by a secondary water coil. The water coil may be supplied by a 2-pipe system, whereby either chilled water or heated water is available, but not simultaneously, or by a 3-pipe system where separate supplies of hot water or chilled water are continuously available and after passing through the unit are mixed into a common return, or by a 4-pipe system, where a supply and return of hot water and chilled water are both continuously available.

The primary supply air fan operates at high pressures requiring high horsepower input. By careful analysis, reduce the primary air volume and pressure to the minimum required to operate the induction terminal units.

Induction unit nozzles may be worn through many years of cleaning and operation resulting an increased primary air quantity at lower air velocities with lower

induced air volumes. Check each induction unit and either repair the nozzles or replace them.

Provide controls to do the following:

Set the primary air reheat schedule as low as possible without causing complaints in the occupied spaces.

Lower the set point of secondary heating water temperatures in winter and schedule according to outdoor conditions.

During maximum cooling or heating periods, reduce the secondary water flow rate to the minimum necessary to obtain satisfactory room conditions.

-Raise temperature of the primary air for cooling to reduce refrigeration load, but weigh this benefit against increased cooling demand by the secondary coils.

-Reduce water temperature to the heating coils during the heating season to reduce piping loss and improve boiler efficiency.

-For night operation during the heating season, shut down primary air fans, raise the hot water temperature and operate the induction units as gravity convectors.

FAN COILS - UNIT VENTILATORS

Fan coil and unit ventilator performance can be improved by careful maintenance which in turn will allow energy savings to be made in the associated heating and cooling water distribution systems. Heating and cooling coils should be cleaned and air and water flow reduced to the minimum required to meet space conditions. Consider changing 4-pipe heating and cooling supply systems to a 2-pipe system. This will avoid changeover loss and prevent simultaneous heating and cooling within a given zone.

-For fan coils systems which have separate coils for heating and air conditioning, install a control to prevent simultaneous heating and cooling.

-Install a seven-day timer to shut down fans, close off valves, and shut off chilled water pumps, compressors and cooling towers or air cooled condensers during unoccupied periods.

-Install controls to shut off fans during unoccupied periods during the heating season and operate the fan coil unit as a gravity convector. (The same is applicable to unit ventilators as well.)

-Block off outdoor air inlets where no dampers are installed if infiltration meets ventilation requirements.

-If fan coil units are not located in conditioned areas, insulate the casings to reduce heat loss/gain.

- With three-pipe systems, set controls for minimum mixing of hot and cold water.

- Change four-pipe or three-pipe systems to two-pipe systems where possible to avoid change-over losses.

WATER-TO-AIR HEAT PUMPS

Air coils should be kept clean to maintain the highest possible seasonal COP. Heat pump units are normally controlled by integral thermostats which turn them on and off according to the demands of space load and these units are frequently left in operation 24 hours/day regardless of whether building is occupied or not.

Install a centralized system of on/off controls on a floor-by-floor basis using a remote control contactor on the power circuit feeding the heat pump. Rewire the power supply to heat pumps in such a manner that 1/3, 2/3, or all of the units in any zone can be turned on and off depending on whether the building is occupied or not and what the expected outdoor conditions are likely to be.

- When retrofitting, install one larger unit rather than multiple smaller units for greater efficiency.

- All guidelines for condensers, compressors, evaporators, fans, pumps, piping and duct work listed in other sections are applicable to unitary closed loop water source heat pumps.

AIR-TO-AIR HEAT PUMPS AND INCREMENTAL AIR CONDITIONING UNITS

- Where possible, direct the warm exhaust air from the building to the inlet of air-to-air heat pumps to raise their coefficient of performance. Waste heat from other processes can also be used as a heat source.

- Replace air-to-air heat pumps with water-to-air heat pumps where there is a source of heat such as ground water with temperatures above average ambient winter air temperatures.

- For incremental air conditioning units follow guidelines for fan coil units during the heating cycle.

- Install a seven-day timer to program operation of compressors in accordance with occupied - unoccupied periods.

- When replacing incremental air conditioning units which are equipped with electric heating coils, install a heat pump model instead.

- Replacement compressors should have an EER rating of 9 or better during cooling cycle. (Applicable also to window air conditioning units).

RADIATION

Radiators, convectors, baseboard, and finned tube units are types of heat-distributing units commonly used in steam and low temperature water heating systems. They supply heat through a combination of radiation and convection, and their function is to maintain the desired air temperature in the space. In general, these types of heat-distributing units should be placed at the points of greatest heat loss of the space, so as to offset or counteract these losses. For example, such units are commonly located under windows, along exposed walls, and at door openings.

Solar Heating Systems

Active Solar Systems

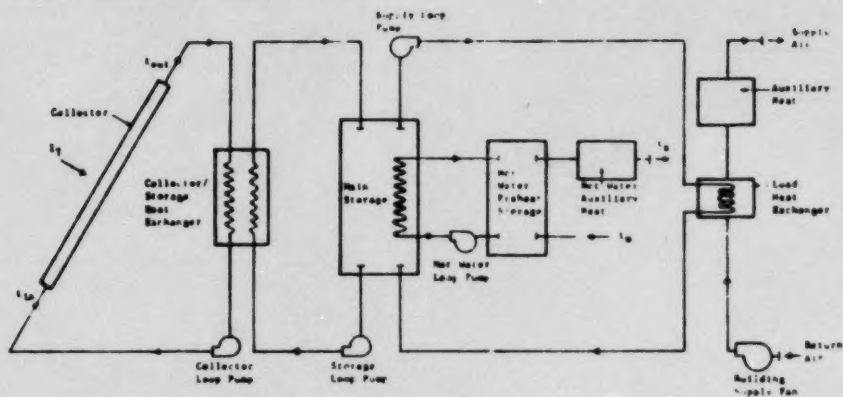
Active solar heating systems are those which use equipment to collect, store, and distribute solar heat in a controlled manner. The systems use solar collectors to heat a fluid which is then pumped or blown to transport the energy from the collector to storage and from storage to the building.

A schematic diagram of a typical liquid-based solar space heating and domestic hot water system is shown in Figure 1. This system uses liquid as the heat transfer fluid and water as the storage medium. Collectors are used to transform incident solar radiation into thermal energy. This energy is stored in the form of sensible heat in a liquid storage tank and used as needed to supply space and water heating loads. If the collectors are not drained at night in cold weather, an antifreeze solution is generally circulated to avoid freezing. In this case, a liquid-to-liquid heat exchanger is used between collectors and the tank because it is more economical than the alternative of using the antifreeze solution as the storage medium.

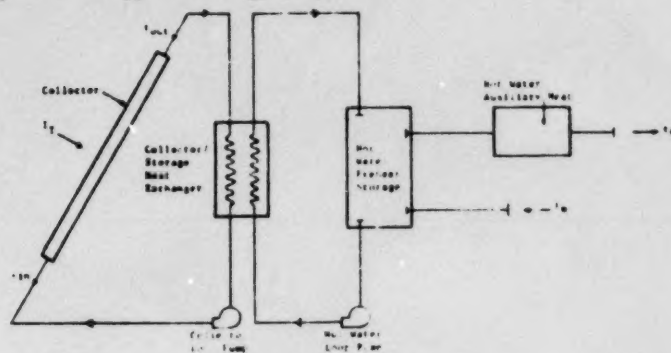
A water-air heat exchanger, referred to as the load heat exchanger, must be used to transfer heat from the storage tank to the building. An additional liquid-to-liquid heat exchanger is used to transfer energy from the main storage tank to a domestic hot water system. A domestic hot water system consists of a preheat tank which supplies solar heated water to a conventional water heater. An auxiliary heater is provided to supply energy for the space heating load when the energy in the storage tank is depleted. Controllers, relief valves, pumps, and pipes make up the remaining equipment. Figure 1 also depicts a schematic diagram of a liquid-based domestic hot water system only.

A schematic diagram of a typical air-based solar space heating and domestic hot water system also shown in Figure 1. Other arrangements of fans and dampers can be devised to result in an equivalent flow circuit. Air is heated in the solar collector and circulated to either the building or to a pebble bed. Energy is stored in the pebble bed by heating the pebbles with the circulating hot air. At night, or in cloudy weather when the available solar energy is insufficient to meet the heating load directly, air is warmed as it is circulated through the warm pebble bed and into the building. Auxiliary heating supplies energy when the energy stored in the pebble bed is depleted. Energy required for domestic hot water is provided in some systems by heat exchange from the hot air leaving the collector to a domestic water preheat tank, as in the liquid system.

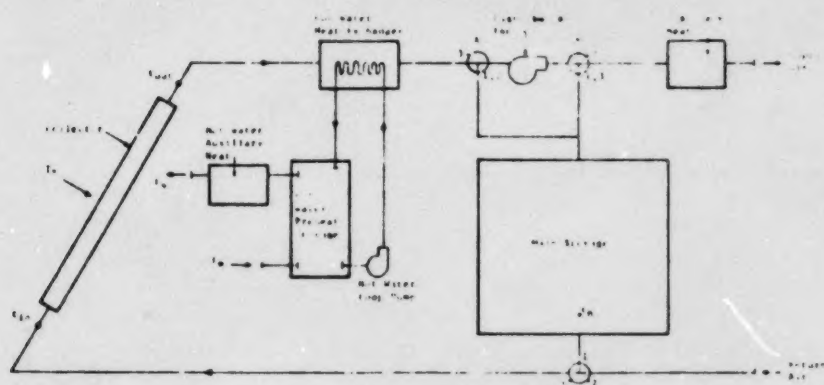
SCHEMATIC DRAWINGS OF BASIC SYSTEMS



a) Liquid System: Space Heating and Domestic Hot Water



b) Liquid System: Domestic Hot Water Only



c) Air System: Space Heating, and Domestic Hot Water

Figure 1

5-16

221

258

Passive Solar Systems

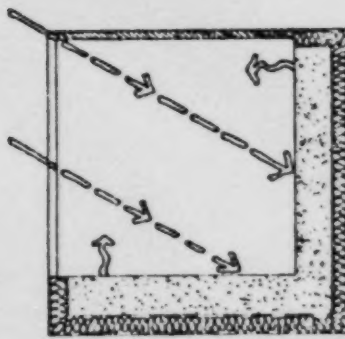
The most widely accepted definition of a passive solar heating and cooling system is one in which thermal energy flows through a building (from collection to storage to distribution) by natural means, enabling the system to function without external power. The operation of a passive system involves the control of the thermal energy flow and includes the ability to completely stop energy flow from escaping or entering the building (eg. shading, insulation), and the ability to vary the timing or location of energy flow inside the building (eg. opening or closing spaces to each other). Control of the system introduces a level of design sophistication which is required in order to achieve the system's operational efficiency.

Both passive heating and cooling systems and their control operations can be inherent in the buildings' construction (for example supporting walls which incorporate mass, insulation, and venting plenums), and in the buildings' organization (spatial hierarchy in response to energy flow tendencies). An efficient passive solar building will show understanding of the cyclic properties of existing climatic forces (suntimes, wind location and speed) on a daily and seasonal basis.

Direct Gain:

The DIRECT GAIN concept is the most common passive solar building solution and has many historic precedents. Simply diagrammed as sun to living space to storage mass, the solar radiation is collected in the living space and then stored in a thermal storage mass. This, the actual living space is directly heated by the sun and serves as a "live-in" collector.

DIRECT GAIN

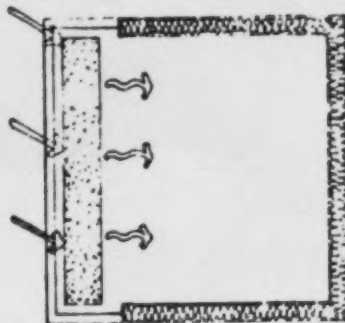


Indirect Gain:

In an indirect gain passive solar building, the fabric of the building continues to collect and store solar energy, but the sun's rays do not travel through the living space to reach the storage mass. This eliminates the Direct Gain temperature limitation whereby solar collection temperatures are limited by occupant comfort needs. Thus, in the INDIRECT GAIN concept, a storage mass collects and stores heat directly from the sun, and then transfers heat to the living space.

One type of INDIRECT GAIN passive solar building type is the Mass Trombe Wall, in which the sun's rays are intercepted directly behind the collector glazing by a massive wall which serves as heat storage.

Mass Trombe Wall



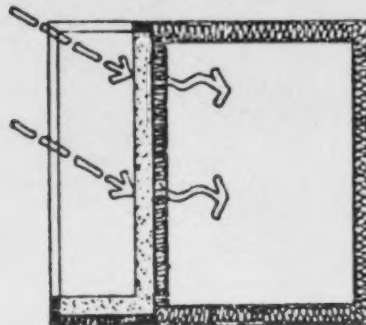
Isolated Gain:

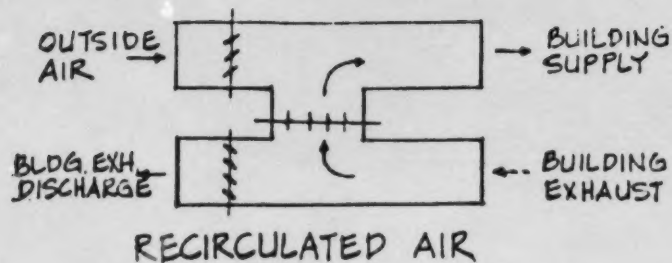
In the ISOLATED GAIN passive solar concept, solar collection and storage are thermally isolated from the living spaces of the building. This concept is contrasted with the DIRECT GAIN passive solar concept where the collection and storage are integral with the living spaces, and with the INDIRECT GAIN concept where collection and storage are separate from the living spaces but directly linked thermally. The ISOLATED GAIN concept thus allows collector and storage to function somewhat independently of the building, while the building can draw from them as its thermal requirements dictate.

The Sunspace ISOLATED GAIN passive building type collects solar radiation in a secondary space which is separate from the living space, and also stores heat for later distribution. This "Sunspace" offers both the potential separation of the collector-storage system from the living space, or the direct gain "live-in" situation which maximizes the use of low temperature solar gain. Thus, in concept, a Sunspace passive solar system is midway between a Direct Gain

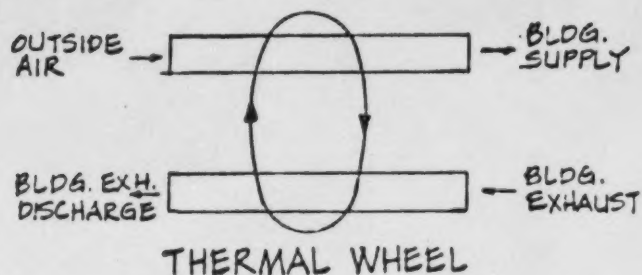
system, in which the living space is the collector of heat, and a Mass or Water Trombe system, which collects heat indirectly for the living space. An atrium, a sun porch, a greenhouse and a sunroom all represent potential examples of a "Sunspace".

Sunspace

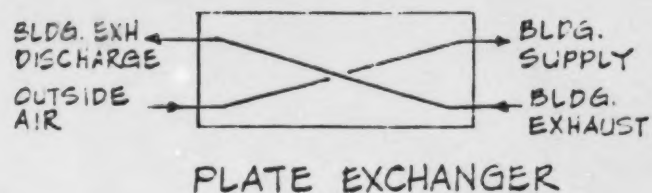




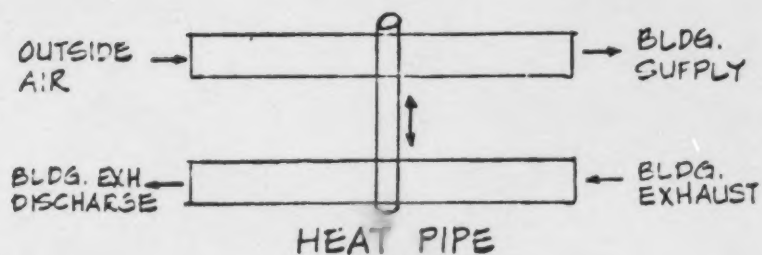
EFFICIENCY
70-90%



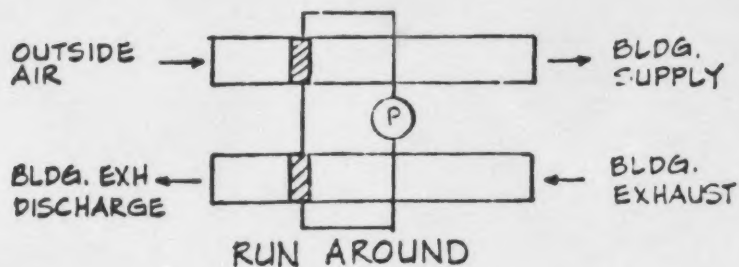
EFFICIENCY
SENSIBLE 70-80%
LATENT 40-60%



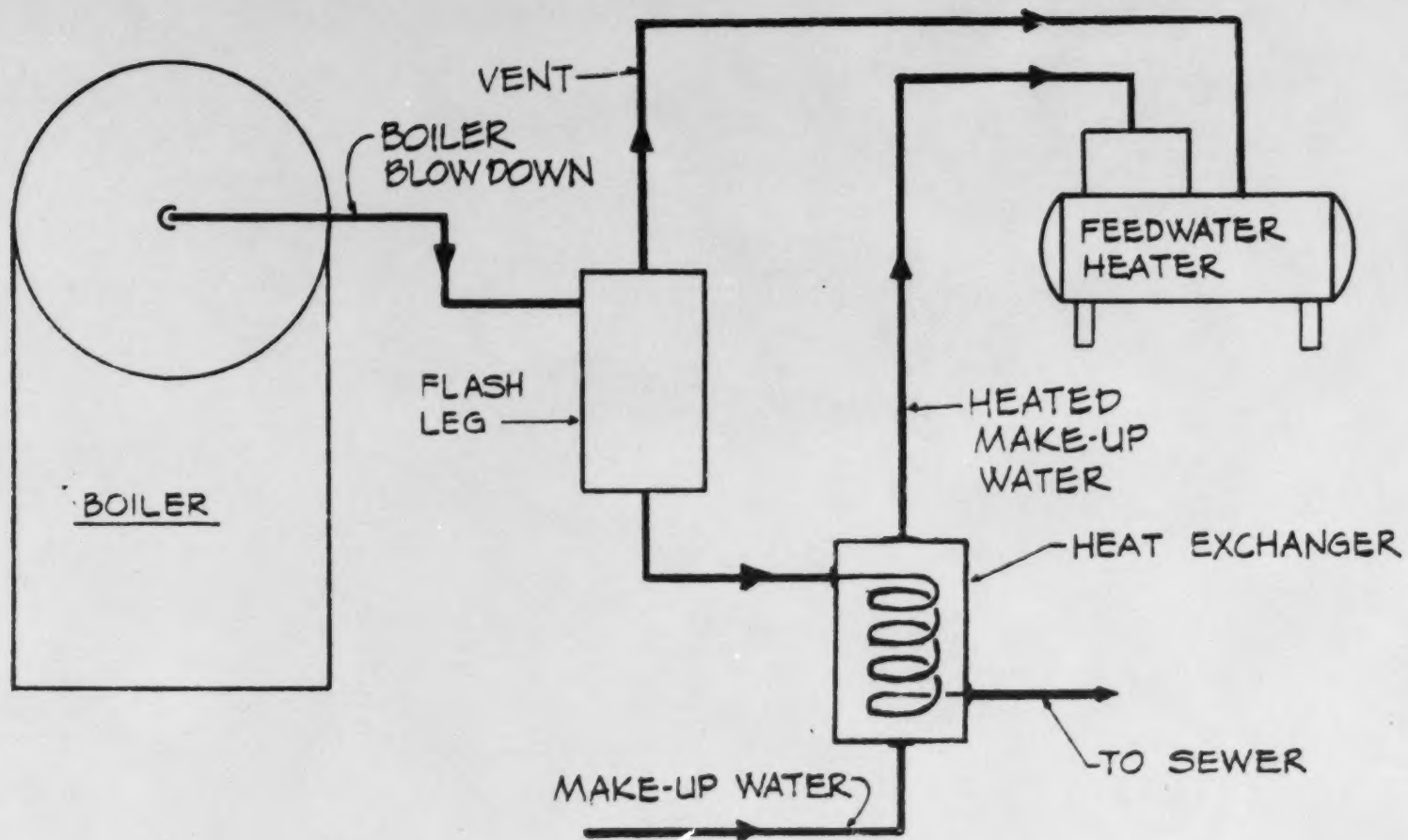
EFFICIENCY
60-75%



EFFICIENCY
50-60%

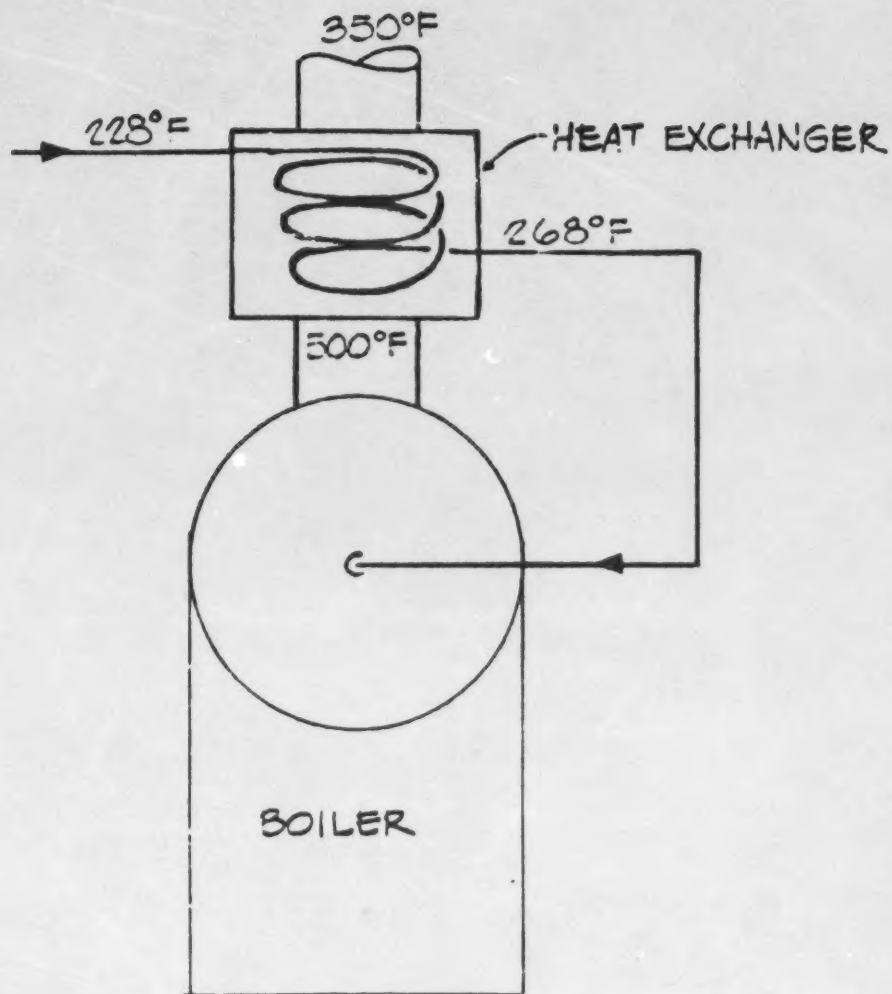


EFFICIENCY
40-60%



CONTINUOUS BLOWDOWN HEAT RECOVERY

284



BOILER FLUE GAS
ECONOMIZER

TOTAL MONTHLY DEGREE DAYS

MONTH	1974 Mon- thly	1975 Mon- thly	1976 Mon- thly	1977 Mon- thly	1978 Mon- thly	1979 Mon- thly	1980 Mon- thly	1974 Cum- lative	1975 Cum- lative	1976 Cum- lative	1977 Cum- lative	1978 Cum- lative	1979 Cum- lative	1980 Cum- lative
January	903	814	774	928	770	1062	984	903	814	774	928	770	1062	984
February	689	737	775	597	617	760	676	1592	1551	1549	1525	1387	1822	1660
March	715	766	789	732	600	632	712	2307	2317	2338	2257	1987	2454	2372
April	536	631	542	485	536	541	455	2843	2948	2880	2742	2523	2995	2827
May	411	298	365	429	406	319		3254	3346	3245	3171	2929	3314	
June	183	260	314	202	143	231		3437	3606	3559	3373	3072	3545	
July	139	134	144	199	135	118		3576	3740	3703	3572	3207	3663	
August	75	187	186	105	141	125		3651	3927	3893	3677	3348	3788	
September	192	259	213	292	247	164		3843	4186	4106	3969	3595	3952	
October	482	479	498	497	452	403		4325	4665	4604	4466	4047	4355	
November	631	686	671	729	816	740		4956	5351	5275	5195	4863	5095	
December	740	808	777	800	925	719		5696	6159	6052	5995	5788	5814	

These degree days are the difference between the average of each day's temperature and 65° F as indicated by the Hidy Degree Day Recorder located at Snohomish County PUD, Everett, Washington.

228

288

287

1. Identify or define:

- a. HVAC
- b. terminal reheat
- c. multi-zone system
- d. prescriptive codes vs. performance codes

2. Suppose that over the next 20 years fuel (electricity) will average \$1.15 per therm (about 4¢/kWh), and that each square foot of a solar water heating system collector will collect about 1 therm each year of energy used by the system. If the system is to be paid back in 20 years or less, what is the maximum allowable per-square-foot cost? (Disregard maintenance, financing, tax credits, etc.)

3. List changes which can typically be suggested in an audit of a nonresidential building in order to conserve energy used in space heating, in water heating, and in lighting: at least four changes in each category, with at least two of these four of low or no cost:

	Space heating	Water heating	Lighting
Low cost changes			
1.			
2.			
Other changes (maybe also low cost)			
3.			
4.			
5.			

ENERGY 210 AUDITING

		DRAFT INDEX	AREA A (in ²)	RESISTANCE R	U=1/R	HEAT LOSS COEF. U X A	THERM/YR HTING FACTOR	LOSS COST THEM
FLOOR	NOW							
	LATER							
CEILING	NOW							
	LATER							
WINDOWS	NOW							
	LATER							
DOORS	NOW							
	LATER							
WALLS	NOW							
	LATER							
AVERAGE								
VOLUME		X		FT ³ X .02				
		=						
INFILTRATION TOTAL			NOW LATER					
CONDUCTION TOTAL			NOW LATER					

NOTES: Draft index # Vo. changes/hr.
 Annual heat loss in therms = Heating factor $\left(\frac{= \text{Degree days} \times 24}{100,000} \right) \times \text{Heat loss coef.}$

CHANGES PROPOSED:
 FLOOR:

DOORS:

CEILING:

WALLS:

WINDOWS:

230 289

Residential Audit Form -- Identification

1. Building site: address (street, city, zip) _____

Telephone: _____

2. Contact person _____

3. Auditor _____ Audit inspection date _____

4. Other parties to receive audit report _____

5. Year structure was built _____

6. Number of stories above slab or basement _____

7. Under main story is: slab ___, crawl space ___, daylight basement ___, underground basement ____.

8. Occupant comments on comfort:

gas oil electric wood other(describe):

9. Primary space heating fuel is _____

Secondary " _____

Water-heater fuel is _____

Other significantly used fuel is _____

10. Primary space-heating method: _____

Secondary space-heating method: _____

(Methods include: central forced-air furnace, central steam boiler + radiators, heat pump forced air, etc. : make clear what converts heat "from fuel" and how heat is delivered.)
If space-heating system is used to heat domestic water, so note.

11. Controls. Thermostat: doesn't exist ___; has day-only set-point ___ usually set at ___;
has day and night settings ___ usually set at ___ and ___.

comments:

12. Last heating season's primary fuel: quantity _____ (gals or kWh) and cost \$ _____.

" secondary " _____

" water-heater fuel _____

(as used for water-heating only) _____

" other fuel _____

13. Degree days: last heating season _____ and long-term _____.

District heating factor: degree days x 24 / (100,000): last season _____ long term _____.

Residential Audit Form -- Heat losses and their costs

Heating Fuel cost,
Factor= \$/therm, =

Bldg site:	DRAFT INDEX	AREA A in ft ²	R-VALUE	U-VALUE (=1/R)	HEAT-LOSS COEF. (=UxA)	THERM/YR LOSS*	\$/YR COST*
Floor now	_____	_____	_____	_____	_____	_____	_____
later	_____	_____	_____	_____	_____	_____	_____
saved	_____	_____	_____	_____	_____	_____	_____
Ceiling now	_____	_____	_____	_____	_____	_____	_____
later	_____	_____	_____	_____	_____	_____	_____
saved	_____	_____	_____	_____	_____	_____	_____
Windows now	_____	_____	_____	_____	_____	_____	_____
later	_____	_____	_____	_____	_____	_____	_____
saved	_____	_____	_____	_____	_____	_____	_____
Doors now	_____	_____	_____	_____	_____	_____	_____
later	_____	_____	_____	_____	_____	_____	_____
saved	_____	_____	_____	_____	_____	_____	_____
Walls now	_____	_____	_____	_____	_____	_____	_____
later	_____	_____	_____	_____	_____	_____	_____
saved	_____	_____	_____	_____	_____	_____	_____
OVERALL* now	_____				_____	_____	_____
later	_____				_____	_____	_____
saved	_____				_____	_____	_____

INFILTRATION LOSS COEF. = VOLUME (in ft³) x .02 x DRAFT INDEX. (OVERALL) , =*NOTES: OVERALL draft index = average of draft index values.OVERALL heat-loss coefficient = total of separate values.

Therm/yr loss = heat-loss coef. x heating factor. \$/yr cost = therm/yr loss x \$ cost/therm.

now	_____	_____	_____
later	_____	_____	_____
saved	_____	_____	_____

OVERALL + INFILTRATION = TOTAL:

now	_____	_____	_____
later	_____	_____	_____
saved	_____	_____	_____

Changes ("now" to "later"):

Floor	_____	Doors	_____
Ceiling	_____	Walls	_____
Windows	_____	Other	_____

B

Condition Summary Page

ADMINISTRATION

- ☐ A-1 Thermostats on heating/cooling units are vulnerable to occupant adjustment.
- ☐ A-2 Thermostat settings have not been adjusted for change in seasons.
- ☐ A-3 Unoccupied or little used areas are heated or cooled unnecessarily.
- ☐ A-4 Off-hour activities are scheduled.
- ☐ A-5 Building temperatures are not adjusted for unoccupied periods.
- ☐ A-6 Heating/cooling equipment is operating in lobbies, corridors, vestibules and/or other public areas.
- ☐ A-7 Heating/cooling equipment is started before occupants arrive and/or is operating during last hour of occupancy.
- ☐ A-8 Use of equipment associated with laundry and custodial services coincides with heavy electrical demand periods.
- ☐ A-9 Blinds and curtains are not used to help insulate the building.
- ☐ A-10 No records of maintenance for motors and motor driven equipment are available.
- ☐ A-11 Control devices are not inspected on a regular basis.
- ☐ A-12 Conditioned air or heated water is discarded.

LIGHTING

- ☐ L-1 Incandescent lamps are used in offices, workrooms, hallways and gymnasiums.
- ☐ L-2 In fixtures where fluorescent lamps have been removed, the ballasts have not been disconnected.
- ☐ L-3 When burned out fluorescent lamps and/or ballasts have been replaced, more efficient lights have not been installed.
- ☐ L-4 Lamps and fixtures are not clean.
- ☐ L-5 Exterior lighting is used.
- ☐ L-6 Lights are on in unoccupied areas.
- ☐ L-7 Natural lighting is not optimized.
- ☐ L-8 Two lamps have not been removed from four-lamp fixtures where possible.

BUILDING ENVELOPE

- ☐ B-1 Improper alignment and operation of windows and doors allows excessive infiltration.
- ☐ B-2 Ceiling/roof insulation is inadequate or has been water damaged.
- ☐ B-3 Weatherstripping and caulking around windows, doors, conduits, piping, exterior joints, or other areas of infiltration are worn, broken or missing.
- ☐ B-4 Excessive expanses of glass exist on exterior walls.
- ☐ B-5 There is no insulation between conditioned and unconditioned spaces.

VENTILATION

- ☐ V-1 An excessive quantity of outdoor air is used to ventilate the building.
- ☐ V-2 Outdoor air intake dampers open when building is unoccupied.
- ☐ V-3 Ventilation systems are not utilized for natural cooling capability.
- ☐ V-4 Exhaust system operation is not programmed.
- ☐ V-5 Return, outdoor air and exhaust dampers are not sequencing properly.
- ☐ V-6 During heating season, temperature of air flow to space feels too cold.
- ☐ V-7 Air flow to space feels unusually low or is inconsistent from one space to another.

Condition Summary Page

HEATING

- ☐ H-1 Multiple boilers or heaters fire simultaneously.
- ☐ H-2 Stack temperature appears excessively high (greater than 400°F plus room temperature).
- ☐ H-3 Water in heating system is heated when there is no need.
- ☐ H-4 Space temperatures are higher or lower than thermostat settings.
- ☐ H-5 Heating system's hot water temperature feels excessively hot during periods of mild weather.
- ☐ H-6 Condensate from street steam is being discharged to sewer drain.
- ☐ H-7 Heating pilot lights are on during cooling season.
- ☐ H-8 Steam radiators or other steam equipment fail to heat or operate erratically.
- ☐ H-9 Steam, condensate and heating water piping insulation is in disrepair or missing.
- ☐ H-10 Operation of oil burner is accompanied by excessive smoke and sooting.
- ☐ H-11 Soot and odors are detected in areas where they are not expected.
- ☐ H-12 Evidence indicates faulty or inefficient boilers or furnaces.
- ☐ H-13 Air is humidified.
- ☐ H-14 Burner short-cycles.
- ☐ H-15 Combustion air to boiler/furnace is not preheated.
- ☐ H-16 Hot water radiation units fail to operate.
- ☐ H-17 Radiators, convectors, baseboards and finned-tube heaters are not providing sufficient heat.

COOLING

- ☐ C-1 Space temperature is higher or lower than thermostat setting.
- ☐ C-2 Chiller is operating during cold weather to provide air conditioning.
- ☐ C-3 Reheat coils are used to maintain zone temperatures.
- ☐ C-4 Multiple air conditioning compressors start at the same time.
- ☐ C-5 Building utilizes a dual duct or multizone system.
- ☐ C-6 Insulation on cooling line pipes and ducts appears inadequate.
- ☐ C-7 Air conditioning load trips circuit breaker on extremely warm days.
- ☐ C-8 Air of inadequate volume or temperature is being discharged through grilles.
- ☐ C-9 Refrigeration condensers or coils are dirty, clogged and/or not functioning efficiently.
- ☐ C-10 Chilled water piping, valves and fittings are leaking.
- ☐ C-11 Chiller operation is not optimized. (Listen for short-cycling.)
- ☐ C-12 Refrigeration compressor short-cycles.
- ☐ C-13 Refrigeration compressor runs continually. (Direct expansion systems.)

WATER

- ☐ W-1 Storage tanks, piping and water heaters are utilized inefficiently.
- ☐ W-2 Drips or leaks are evident in hot water systems.
- ☐ W-3 Electric water heater has no time restrictions on heating cycle.
- ☐ W-4 Devices to conserve heated water have not been utilized where practical.

*Energy Bills for Sambo's Everett
vs. (audited) Sambo's Lynnwood*

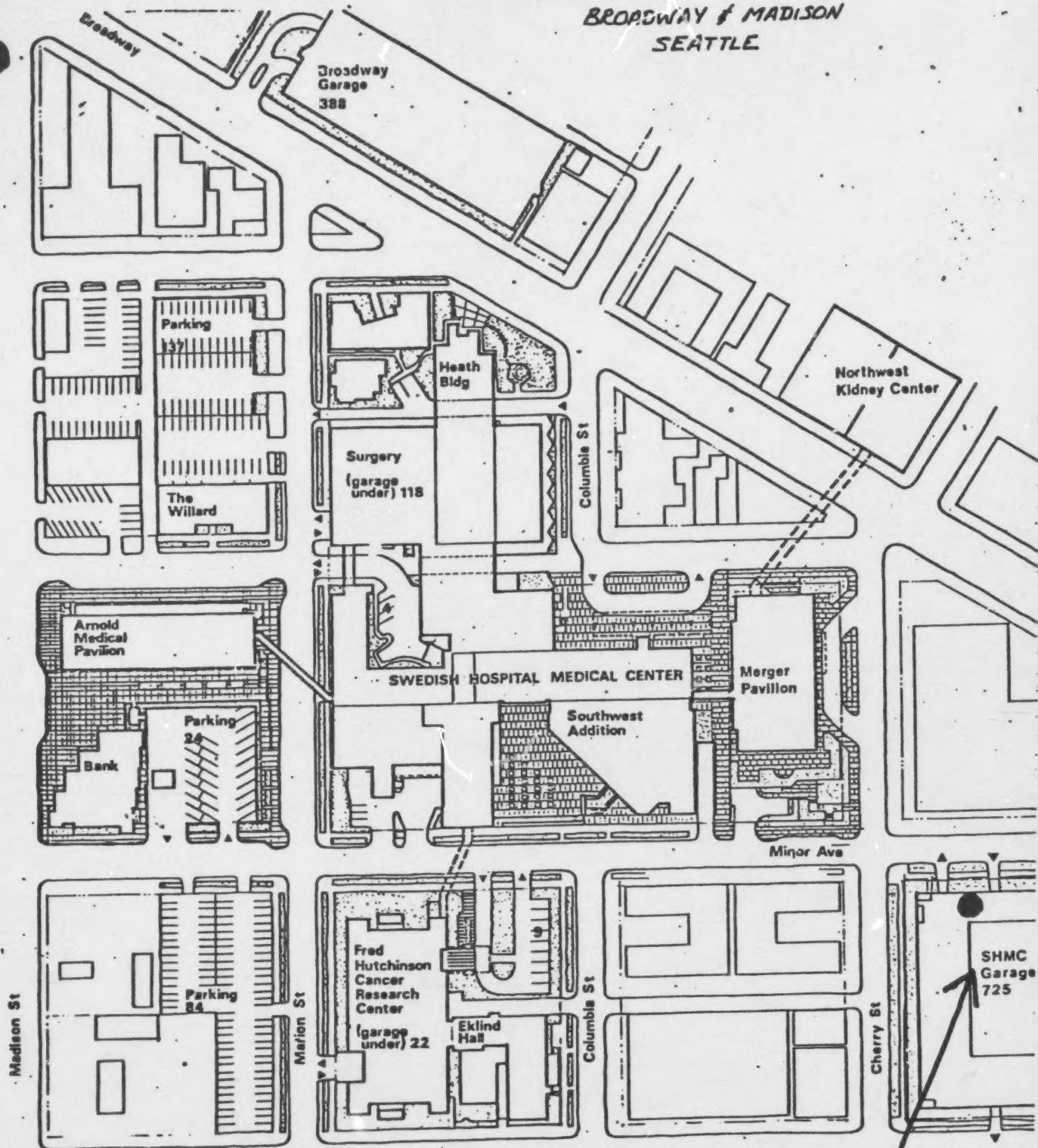
521421833602
ACCT 5214 218336 02 4 STAT ACTIVE
NAME SAMBO'S EVERETT 190
S/A 10020 EVERGREEN WY
M/A
PO BX 568
CARPINIERIA CA 93013
POLE 1P W P&O
TAX CODE 07
P/R 00/00/00 C/I DATE 04/29/81
EV4 SIO 500
DLT 04/09/80
LAST R/R 03/21/80
CR TOT 0
METER 1
METER NUMBER 105437 SCHEDULE 20 REVENUE CLASS 32 SERVICE CODE 1 BALANCE \$1.00
DATE CODE KWH/CF AMOUNT BILL DEM TXCD
03/21/80 11111 29520 \$431.93 09 METER STATUS NORM
01/22/80 11111 32720 \$445.06 09 PREV READING 4670
11/19/79 11111 31360 \$412.32 09 PREV READING 4501
09/20/79 11111 35040 \$456.48 09 LOCATION 65
07/23/79 11111 36800 \$477.60 09 RDG SEQUENCE 730
05/22/79 18111 32720 \$428.64 09 BILL CODE 0
03/22/79 11111 35520 \$462.24 09 NUMBER DIALS 4
01/22/79 11121 36960 \$483.12 09 CONNECTED LOAD 10.0
11/17/78 11111 31040 \$408.48 09 MULTIPLIER 80
09/20/78 11111 35200 \$458.40 09 DEMAND SCALE
07/21/78 11111 34060 \$433.84 09 SPECIAL MIN \$4.00
05/22/78 11111 30880 \$338.80 09
03/22/78 11111 31360 \$343.60 09
01/20/78 11111 32560 \$355.60 09

81142275/902
ACCT 8114 227579 02 7 STAT ACTIVE
NAME SAMBO'S *957
S/A 4626 196TH ST SW
M/A
PO BX 568
CARPINIERIA CA 93013
POLE
TAX CODE 12
P/R 03/03/78 C/I DATE 11/18/77
LY SIO 500
DLT 03/21/80
LAST R/R 03/21/80
CR TOT 0
METER 1
METER NUMBER 108398 SCHEDULE 20 REVENUE CLASS 32 SERVICE CODE 3 BALANCE \$614.83
DATE CODE KWH/CF AMOUNT BILL DEM TXCD
03/21/80 11111 42240 \$608.74 12 METER STATUS NORM
01/22/80 11111 51840 \$686.99 12 PREV READING 5953
11/19/79 11111 42880 \$550.56 12 PREV READING 4789
09/20/79 11111 50240 \$638.88 12 LOCATION 50
07/23/79 11111 36480 \$473.76 12 RDG SEQUENCE 391
05/22/79 18111 59840 \$754.08 12 BILL CODE 0
03/22/79 11111 59680 \$752.16 12 NUMBER DIALS 4
01/22/79 11121 68320 \$859.44 12 CONNECTED LOAD 269.0
11/17/78 11111 60000 \$756.00 12 MULTIPLIER 160
09/20/78 11111 70880 \$886.56 12 DEMAND SCALE
07/21/78 11111 67040 \$819.47 12 SPECIAL MIN \$133.50
05/22/78 11111 61280 \$642.80 12
03/22/78 11111 51200 \$542.00 12
01/20/78 11111 71360 \$743.60 12

HOSPITAL HVAC SYSTEM TOUR

4-26-80

BROADWAY & MADISON
SEATTLE



N ←

MEET AT NEW PARKING GARAGE 8:30 A.M.

SWEDISH HOSPITAL MEDICAL CENTER

230 275

CHAPTER 1

MAINTENANCE AND OPERATIONAL CHANGES

By diligently following a maintenance program, a restaurant owner or manager can conserve a substantial quantity of energy by maintaining the building at its optimum designed conditions. Energy saved as a result of such a program is obviously dollars saved, since little or no capital investment is required.

To conduct a continuing energy conservation/maintenance program, a checklist of items to be done on a regular basis should be set down and followed faithfully. This section of the workbook is in the form of a checklist that will aid in identifying maintenance and operational changes that will result in energy conservation.

The general energy users in a restaurant have been categorized into headings such as space heating, air conditioning, ventilation, etc. Under these broad categories the pertinent maintenance and operational changes have been listed.

Several of the items listed have been shown to be particularly applicable to most restaurants since they result in the quickest energy and dollar savings. For reference they are as follows (they will also appear in their respective functional headings in this chapter):

1. Lower the thermostats during the heating season and raise them during the cooling season. You can save about 8% of your heating fuel bill by lowering the thermostats a mere five degrees.
2. Examine the entire building for air leaks around windows, doors and any place that they might occur. Seal up the leaks.
3. Use night set backs on heating systems. Maintaining 55°F at night will reduce energy consumption by 5% to 6% during the night hours.
4. Check all automatic temperature controls to determine if they are working properly.
5. Turn off cooking and heating units that are not needed.
6. Close off dining areas not in use.
7. Stagger turn-on times for heavy duty electrical equipment so that thirty minute intervals can be achieved.
8. Turn on food warmers only as needed.
9. Use a second fry unit, broiler, oven, etc., only for peak business hours.

10. Determine a schedule of preheating times for ovens, steam cookers, grills, broilers, fry vats, etc. Generally 10 to 30 minutes, depending on appliance, is adequate.
11. Set up and run a total maintenance program for all equipment. Equipment which operates properly consumes less energy than improperly operating equipment.
12. Load and unload ovens quickly to avoid unnecessary heat loss.
13. Make the monthly energy consumption and cost data available to the manager and chief operating engineer so that they can evaluate and compare against previous months and normal budget.
14. Involve the employees in the goals of energy conservation.

After reading through the check list pick up a pencil, put on your walking shoes, and start walking through the building. Examine the suggested maintenance and operational changes that pertain to your restaurant. Make notes as you go along. Accomplish the items that can be done immediately, then explore the possibility of doing the other steps which may require more information or advice. Start incorporating the applicable preventative maintenance items into a regular program immediately.

FILMS AND RESOURCE REFERENCES

ENERGY 210 - ENERGY AUDITING/CALCULATIONS

FILMS AND RESOURCE REFERENCES

ENERGY 210 - ENERGY AUDITING/CALCULATIONS

REFERENCES

Descriptive Energy Management, by Aadland and Hoffman, AHP Energy Associates, Inc., 1979

The Energy Controversy, published by Friends of the Earth, 1979

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY

211

*Course abbrev.

*Course number

Check ONE: ☒ NEW COURSE PROPOSAL: complete ALL items below.
☐ SYLLABUS UPDATE: complete only items marked with asterisk (*).
☐ REVISION: specify change _____

*COURSE TITLE: Commercial Buildings

STUDENT CLASS HOURS:	<u>55</u>						
	<u>lect.</u>	<u>lect/</u>	<u>lab</u>	<u>shop</u>	<u>clin.</u>	<u>other</u>	<u>syst.</u>
		<u>lab.</u>					
<u>5</u>	<u>55</u>	<u>35</u>	<u>.333</u>				
Credits	Instructor	Capacity (est.)	FTEF fraction	Fee	HEGIS code		
	contact hrs.						

PREREQUISITE: CONST 170 and ENRGY 100

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer ☐ occupational preparatory ☐ community service
☐ academic basic ☒ occupational supplementary
☐ academic general ☐ occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

LISTING: one (and ONLY one) MUST be checked.

AAS distribution	☐ ()	AAS electives	☐ ()	AAS electives	☒ ()
(transfer only)	yes no	(transfer only)	yes no	(15 credit	yes no
				block)	

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ () ☒ (X)
 yes no

CATALOG DESCRIPTION:

This course will discuss the many different types of commercial buildings, construction techniques and materials in both new and existing structures. Topics covered will include: mechanical and electrical systems and their operation, thermal balancing, and maintenance. It will also focus on knowledge and skills needed for industrial energy auditing, as well as for energy-conscious building design. Field studies and student projects will include industrial energy audits. Prerequisite: CONST 170 and ENRGY 100.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

1. Student will become aware of the many different types of commercial buildings: their differences according to usage, materials, construction methods -- especially in regard to energy use.
2. Student will review and extend knowledge of various HVAC systems in commercial buildings: their overall design, their components, their operating conditions, their basic maintenance and startup.
3. Student will learn basics of electrical systems and electricity-consuming machinery typically used in industrial and commercial buildings: basics concerning operation, maintenance, and energy use and conservation.
4. Student will integrate above knowledge through performance of industrial/commercial energy audits.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

1. Instructor or guest lectures
2. Discussion, class participation
3. Field trips to industrial and commercial buildings directed toward two objectives: basic familiarization with appearance and features of HVAC and other equipment, increasing practices in on-site inspection phases of industrial/commercial energy auditing.
4. Student projects: independent commercial/industrial energy audits.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Mid-term and final examinations will be required.

Progress checks will also be required and may be in the form of any of the following:

1. Workbook
2. Worksheets
3. Quizzes
4. Projects

***GRADING:**

<u>Course Standards:</u>		<u>Grading Schedule</u>	
attendance/participation	25%	90-100%	A
assignment/homework	25%	80-89%	B
or projects		70-79%	C
written examinations	50%	60-69%	D
(mid-term and final)		59% or below	E
Curve grading will not be accepted!!!			

Course standards are flexible, however, instructor must get program coordinator's approval to change.

*DETAILED COURSE OUTLINE:

Week by week:

1. Introduction. Survey of types of commercial buildings, Classification by usage. Survey of materials and methods used in construction. Energy use in commercial buildings: facts, and conservation opportunities.
2. Field trip. Function and appearance of HVAC components.
3. Field trip. Maintenance of HVAC components.
4. Field trip. HVAC systems and their appearance. Startup and balancing
5. Field trip. Electrical systems. Typical sources of electrical energy requirements.
6. Field trip. Choice, operation and maintenance of electric motors. Midterm
7. Energy management programs in commercial and industrial buildings.
8. Field trip. Auditing as tool in energy management.
- 9-10. Student auditing projects. Completion, In-class discussion and review.
11. FINAL

TEXT REFERENCES Instruction for Energy Auditors. USDOE Vols 1 and 2 with its Supplements on various types of commercial buildings.
Also: text and audit checklist, WSEO Schools and Hospitals NECPA program.

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

	<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1.	_____	Course proposal form submitted to the office of the associate dean of instruction	_____
2.	_____	Page one completed.	
3.	_____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4.	_____	Reviewed by director of learning center	_____ (DLR)
5.	_____	Reviewed by Faculty-Administration Council.	
6.	_____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7.	_____	Course proposal form filed in temporary location.	
8.	_____	Pages two and three completed (prior to the end of the quarter in which taught).	
9.	_____	Page four completed.	
10.	_____	Course proposal form filed in permanent location.	

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY 220
 *Course abbrev. *Course number

Check ONE: ☒ NEW COURSE PROPOSAL: complete ALL items below.
☐ SYLLABUS UPDATE: complete only items marked with asterisk (*).
☐ REVISION: specify change _____

*COURSE TITLE: Energy Control Systems

STUDENT CLASS HOURS:		33						
		lect.	lect/ lab.	lab	shop	clin.	other	syst.
3	33		35		.20			
Credits	Instructor contact hrs.	Capacity (est.)	FTEF fraction	Fee	HEGIS code			

PREREQUISITE: Electronics 115, Energy 110 and 210 or equivalent experience with permission of coordinator.

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer ☐ occupational preparatory ☐ community service
☐ academic basic ☒ occupational supplementary
☐ academic general ☐ occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

Course designed to serve persons enrolled in the Energy Management program and others with career goals in the energy field.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution	☐ ()	AAS electives	☐ ()	AAS electives	☒ ()
(transfer only)	yes no	(transfer only)	yes no	(15 credit block)	yes no

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ () ☒ (X)
 yes no

CATALOG DESCRIPTION:

Energy Control Systems will provide an in-depth study of the function and use of devices that regulate energy use in buildings. Both manual and automatic control of simple switches through programmable microprocessors will be studied with emphasis on conserving energy. Core material including control logic plus several guest speakers from the controls industry provide an interesting and informative format. Prerequisite: ENRGY 110, 210, and Electronics 115 or equivalent experience with permission of coordinator.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

1. Student will become aware of the basic task of a control mechanism-- to alter a system, based on relevant data about the state of the system and about the state of the environment.
2. Student will become aware of the range of mechanisms for realizing this task in energy use.
3. Logic: student will become aware of how an entire system's control requirements may be analyzed into basic requirements which reduce to switching. Student will master elements of performing such analysis.
4. Student will become aware of capabilities of existing control equipment, in particular of microprocessor controls.
5. Student will demonstrate ability to integrate above awarenesses into a project for ~~designing a control system, for a building's energy systems~~

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

1. Instructor lectures and demonstration.
2. Discussion, class participation.
3. Student design projects for control of energy systems in residences or small commercial buildings, with emphasis on defining functions, developing logic, and specifying hardware.
4. Lectures and demonstrations by guests from the controls industry.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Mid-term and final examinations will be required.

Progress checks will also be required and may be in the form of any of the following:

1. Workbook
2. Worksheets
3. Quizzes
4. Projects

***GRADING:**

Course standards:

attendance/participation	25%
assignment/homework	25%
or projects	
written examinations	50%
(mid-term and final)	

Grading schedule:

90-100%	A
80-80%	B
70-79%	C
60-69%	D
59% or below	E

Curve grading will not be accepted!

Course standards are flexible, however, instructor must get program coordinator's approval to change.

*DETAILED COURSE OUTLINE:

1. Introduction. Survey of controls: their functions, their operating mechanisms, their role in energy use and conservation in buildings.
Class development of as many different examples as possible of on/off mechanisms used to control energy use, and of as many different examples as possible of operating means -- manual, mechanical, thermal, electronic. (From opening and closing doors and dampers, to switching on lights and beadwall, to setting thermostats, to...?)
Single operation (light switch) vs. automatic cycling/restart (thermostat).
Feedback concepts.
2. Simple-logic automatic devices. Timer. One-setpoint thermostats.
Review of switching to implement simple logical operations: and, or, if-then, etc.
3. Analyzing logical requirements. Multizone single-setpoint thermostats and other not-too-complex situations. Solar water heater differential thermostats.
4. Available temperature and other sensors and their use.
5. Available information recording equipment, and use of stored information or programs for control.
6. Review. Mid-term. Introduction to student project.
- 7-9. Programming possibilities for complex control systems. Guest speakers from controls industry on hardware possibilities. Consultation on student projects.
10. Review. Students describe projects to class. Opportunities in controls industry and energy control systems design.
11. FINAL.

TEXTS/REFERENCES: Materials on controls used in Energy 210, Auditing and Energy 211, Commercial buildings. Handouts on logic and programming course portions. Handouts from controls industry.

Special student assignments: TERM PROJECT: Design or remodel the energy systems controls in a residence or small commercial building -- or elsewhere, as approved by instructor.

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1. _____	Course proposal form submitted to the office of the associate dean of instruction	_____
2. _____	Page one completed.	
3. _____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4. _____	Reviewed by director of learning center	_____ (DLR)
5. _____	Reviewed by Faculty-Administration Council.	
6. _____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7. _____	Course proposal form filed in temporary location.	
8. _____	Pages two and three completed (prior to the end of the quarter in which taught).	
9. _____	Page four completed.	
10. _____	Course proposal form filed in permanent location.	

VJD:101979

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY

230

*Course abbrev.

*Course number

Check ONE: ☒ NEW COURSE PROPOSAL: complete ALL items below.
☐ SYLLABUS UPDATE: complete only items marked with asterisk (*).
☐ REVISION: specify change _____

*COURSE TITLE: Advanced Solar Energy Concepts

STUDENT CLASS HOURS: 33 lect. lect/ lab shop clin. other syst.
lab.

3 33 20
Credits Instructor Capacity (est.) FTEF fraction Fee HEGIS code
contact hrs.

PREREQUISITE: ENRGY 130

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer ☐ occupational preparatory ☐ community service
☐ academic basic ☒ occupational supplementary
☐ academic general ☐ occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

LISTING: one (and ONLY one) MUST be checked.

AAS distribution ☐ ☐ AAS electives ☐ ☐ AAS electives ☒ ☐
(transferr only) yes no (transferr only) yes no (15 credit yes no
block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ ☒
yes no

CATALOG DESCRIPTION:

This course will include detailed analysis of solar heating and cooling systems in residential and industrial applications, and the integration of solar with other heating systems. Photo-electric conversion will also be studied. Other topics will include: equipment survey, installation techniques and control systems. Prerequisite: ENRGY 130

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

Upon completion of this course, the student will:

1. Have had performed design calculations for common types of solar systems, both active and passive.
2. Be thoroughly familiar with the system details of solar applications.
3. Be familiar with and comparison of thermal storage systems and their sizing.
4. Familiarity with sizing methods of heat exchangers.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

Lecture with class participation

Field tripw will be incorporated to study existing solar energy systems in the local community.

Guest speakers will be utilized.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Mid-term and final examinations will be required.

Progress checks will also be required and may be in the form of any of the following:

1. worksheets
2. workbook
3. quizzes
4. projects

***GRADING:**

Course standards:

attendance/participation	25%
assignments/homework	25%
or projects	
written examinations	50%
(mid-term and final)	

Grading Schedule:

90-100%	A
80-89%	B
70-79%	C
60-69%	D
59% or below	E

Curve grading will not be accepted.

Course standards are flexible, however, instructor must get program coordinator's approval to change.

*DETAILED COURSE OUTLINE:

- I. Passive Systems
 - A. Direct Gain
 - Insulation
 - Shading
 - Thermal mass
 - B. Trombe Wall
 - Sizing
 - Footing supports
 - C. Greenhouses
 - Insulation
 - Heat loss
 - Storage Sizing
 - Water
 - Rock
 - Salt
 - Combination
 - D. Rock Bins
 - Passive-Hybrid
 - Active
- II. Active Systems
 - A. Domestic hot water
 - Collector, Storage, pump
 - B. Space Heating
 - Collector sizing - F-chart
 - Storage Design
 - Water, rock, salt, combinations
 - Blowers and pumps
 - C. Heat exchanger sizing

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

	<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
*1.	_____	Course proposal form submitted to the office of the associate dean of instruction	_____
2.	_____	Page one completed.	
3.	_____	Division recommends approval () Division recommends disapproval ()	_____ (DR)
4.	_____	Reviewed by director of learning center	_____ (DLR)
5.	_____	Reviewed by Faculty-Administration Council.	
6.	_____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
7.	_____	Course proposal form filed in temporary location.	
8.	_____	Pages two and three completed (prior to the end of the quarter in which taught).	
9.	_____	Page four completed.	
10.	_____	Course proposal form filed in permanent location.	

EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY

285

*Course abbrev.

*Course number

Check ONE: ☒ NEW COURSE PROPOSAL: complete ALL items below.
☐ SYLLABUS UPDATE: complete only items marked with asterisk (*).
☐ REVISION: specify change _____

*COURSE TITLE: Energy Building Codes and Regulations--NEW TITLE

STUDENT CLASS HOURS: 33 lect. lect/
lab. lab shop clin. other syst.

3 Credits 33 Instructor contact hrs. 35 Capacity (est.) .20 FTEF fraction Fee HEGIS code

PREREQUISITE: Required: CONST 280, Recommended: ENRGY 210 and 211

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

☐ academic transfer ☐ occupational preparatory ☐ community s
☐ academic basic ☒ occupational supplementary
☐ academic general ☐ occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

Students enrolled in the Energy Management Program.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution ☐ ☐ AAS electives ☐ ☐ AAS electives ☒ ☐
 (transfer only) yes no (transfer only) yes no (15 credit yes no
 block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? ☐ ☒
 yes no

CATALOG DESCRIPTION:

Codes and regulations affecting energy use in buildings through restrictions on design or operations. Focus on new energy conservation codes. Heed also to energy impacts of traditional construction-related codes, and of other regulations. Survey of energy-impacting standards for equipment, for building systems and construction practices, and for land-use decisions and community development. Class work and student projects will feature specific design projects for new or remodeled residences and commercial buildings, used as case studies of effects of energy-related codes and regulations. Prerequisites: CONST 280 required, ENRGY 210 and 211 recommended.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

1. Student will become aware of the range of energy-impacting codes and regulations, and the scope and impact of each on building operations and building design.
2. Student will, by case study, become aware of typical design problems posed by energy-impacting codes and regulations, and how these problems may be solved.
3. Student will become aware of historical and impending trends in construction-related regulation having intended or unintended effects on energy in building operations and design. Student will become aware of opportunities, as citizen and as professional, to influence the future course in this area.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

1. Instructor lectures.
2. Discussion, class participation.
3. Student design projects, emphasizing student documentation of impact of codes and regulations in restricting or forcing design choices relating to energy-consuming or energy-saving features of the building (or community)
4. Guest lectures on specific areas of regulation or on how energy-conscious design copes with such regulation.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Mid-term and final examinations will be required.

Progress checks will also be required and may be in the form of any of the following:

1. Workbook
2. Worksheets
3. Quizzes
4. Projects

Student project--written in full, or written in outline and delivered orally to class.

***GRADING:**

Course standards:

Attendance/participation	25%
assignments/homework	25%
or projects	
written examinations	50%
(mid-term and final)	

Curve grading will not be accepted.

Course standards are flexible, however, instructor must get program coordinator's approval to change

Course Grading schedule:

90-100%	A
80-89%	B
70-79%	C
60-69%	D
59% or below	E

***DETAILED COURSE OUTLINE:**

1. Introduction. Survey of construction-related regulations and their classification. Classification: by scope -- equipment, systems, practices, land-use, etc.; by intent and concern -- durability, health, safety, etc.; by type of demand: prescription-oriented, performance oriented, etc. Important specific examples: UBC, etc.
2. Process of making, revising, administers: standards, codes, regulations. Case studies: local building code; WA State Energy Code (1980).
3. Materials and equipment: surveys and examples of standards, codes, regulations. Insulation materials, solar equipment, etc.
4. Building systems and construction practices: codes and regulations. Survey: Energy Codes. Traditional Codes. Other regulations (e.g., emergency building temperature requirements.) Development of WA State Energy Code from ASHRAE standard 90-75, etc.
5. Land-use and community development regulations and policies (including zoning codes). Solar siting, solar access. MIDTERM.
6. Impact of codes and regulations. In-class case study involving design of a new residence.
7. Conclude 6. Second case study involving design of a residential remodel.
8. Third case study involving overview of design of a commercial or institutional building.
9. New trends in energy-impacting codes and regulations. Oral reports of student projects.
10. Conclude 9. Review.
11. FINAL

Special studnet assignments: Term project: Design a new or remodeled residence or a new or remodeled commercial building, or community, with emphasis on documenting impact at each stage of codes and regulation--insofar as these regulate or force design choices relating to energy-consuming or energy-saving features of the construction.

TEXT/REFERENCES: Washington State Energy Code 1980. Snohomish PUD Standards for Energy Efficient Homes.

Standard ASHRAE 90-75, Energy Conservation in New Building Construction.
HUD Intermediate Minimum Property Standards, Solar Domestic Water Systems.
"Solar Law"

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

	<u>Date</u>	<u>Procedure</u>	<u>By (signature):</u>
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6.	_____	Dean of instruction approves () Dean of instruction disapproves ()	_____ (DI)
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9.	_____	Page four completed.	
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COURSE PROPOSAL FORM

Check ONE: (X) NEW COURSE PROPOSAL: complete ALL items below.
() SYLLABUS UPDATE: complete only items marked with asterisk (*).
() REVISION: specify change

STUDENT CLASS HOURS:

<u>1</u> Credits	<u>11</u> Instructor contact hrs.	<u>30</u> Capacity (est.)	<u>FTEF fraction</u>	<u>Fee</u>	<u>HEGIS code</u>

() academic transfer (x) occupational preparatory () community service
() academic basic () occupational supplementary
() academic general () occupational "useful"

2nd year energy students or equivalent background.

AAS distribution	() ()	AAS electives	() ()	AAS electives	(X) ()
(transfer only)	yes no	(transfer only)	yes no	(15 credit block)	yes no

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? () (X)
yes no

For studnets enrolled in Energy Cooperative Education. A career-related course designed to assist students in developing their job objectives, exploration of career options, and the development of work attitudes.

*COURSE OBJECTIVES (standards against which student performance will be evaluated):

1. To provide a method of analyzing important task functions that are most important in the student's job.
2. To provide a method of analyzing various organizational structures.
3. To provide a method for understanding the advantages and disadvantages of the energy industry in the Greater Seattle/Puget Sound area.
4. To provide a method of analyzing problem areas related to work assignment and suggestions for correction.
5. To provide a method for identifying and describing a career progression ladder and describe one career goal per year.

*METHODS OF INSTRUCTION: (includes also special requirements for materials, space, support)

Seminar materials related to a specific energy occupation will be chosen at the discretion of the co-op coordinator and/or faculty advisor. Materials must be suitable to each individual and his/her career goals.

*EXAMINATIONS (methods of evaluating student attainment of objectives):
Student progress will be evaluated by the following method: each completed assignment under course outline is worth 10 points.

*GRADING:

50 points.....	A
40 "	B
30 "	C
20 "	D

*DETAILED COURSE OUTLINE:

Co-op seminars will be held one hour per week to discuss the work assignment, student progress and results. Participation by representatives of the Career Exploration Center and industry will be asked to make the learning experience more meaningful. Students will be asked to complete the following:

1. List and describe at least 10 or more specific task functions that are most important in his/her job.
2. Identify and describe the organizational structure of the work site.
3. Describe the advantages and disadvantages of the energy industry in the Greater Seattle/Puget Sound area.
4. List and describe five problem areas related to the work assignment and suggestions for correction action.
5. Identify and describe a career progression ladder in the energy industry as well as identifying a career goal for the next year.

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

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9. _____	Page four completed.	
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COURSE PROPOSAL FORM

Check ONE: (X) NEW COURSE PROPOSAL: complete ALL items below.
() SYLLABUS UPDATE: complete only items marked with asterisk (*).
() REVISION: specify change

STUDENT CLASS HOURS:

Maximum:

3 qtrs/15 cr.

PREREQUISITE: Coordinator's permission and concurrent enrollment in Energy 292

() academic transfer (X) occupational preparatory () community service
() academic basic () occupational supplementary
() academic general () occupational "useful"

Energy Management students.

AAS distribution (transfer only)	() () yes no	AAS electives (transfer only)	() () yes no	AAS electives (15 credit block)	(X) () yes no

CATALOG DESCRIPTION:

Students are employed in a career-related work assignment in the community, coordinated by the college and the employer, to provide on-the-job training as a learning experience.

*COURSE OBJECTIVES (standards against which student performance will be evaluated):

1. With the assistance of employer and instructor, student prepares a series of work objectives to be accomplished during the training period.
2. Student's goal is to increase job knowledge and improve skills. At the end of work experience evaluate in writing how the work objectives contributed toward his/her career goals.

*METHODS OF INSTRUCTION: (includes also special requirements for materials, space, support)

Instruction will be provided by supervising employer to assist student in achieving work objectives. Student's objectives must be individualized to meet student's career goals.

*EXAMINATIONS (methods of evaluating student attainment of objectives):

Student progress and desirability of the work station will be evaluated by a combination of methods:

1. An initial job description will be written with periodic student-employer critiques to determine goals being met, methods being used and revisions needed to insure on-the-job progress.
2. Work-site visits by the coordinator or sponsoring faculty member and discussion with the supervisor.
3. Employer's written evaluation of co-op student.

*GRADING:

S or U

*DETAILED COURSE OUTLINE:

To be developed by student/employer/co-op coordinator/faculty advisor

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

- | | <u>Date</u> | <u>Procedure</u> | <u>By (signature):</u> |
|-----|-------------|---|------------------------|
| *1. | _____ | Course proposal form submitted to the office of the associate dean of instruction | _____ |
| 2. | _____ | Page one completed. | |
| 3. | _____ | Division recommends approval ()
Division recommends disapproval () | _____
(DR) |
| 4. | _____ | Reviewed by director of learning center | _____
(DLR) |
| 5. | _____ | Reviewed by Faculty-Administration Council. | |
| 6. | _____ | Dean of instruction approves ()
Dean of instruction disapproves () | _____
(DI) |
| 7. | _____ | Course proposal form filed in temporary location. | |
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| 9. | _____ | Page four completed. | |
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EDMONDS COMMUNITY COLLEGE

COURSE PROPOSAL FORM

ENRGY 299
 *Course abbrev. *Course number

Check ONE: (X) NEW COURSE PROPOSAL: complete ALL items below.
 () SYLLABUS UPDATE: complete only items marked with asterisk (*).
 () REVISION: specify change _____

*COURSE TITLE: SPECIAL PROJECTS/INDEPENDENT STUDY

STUDENT CLASS HOURS: 11-55
 lect. lect./lab. lab. shop clin. other syst.

1-5 5 .02/student
 Credits Instructor Capacity (est.) FTEF fraction Fee HEGIS code
 contact hrs.

PREREQUISITE: ALL ENERGY 100 LEVEL COURSES AND/OR INSTRUCTOR'S PERMISSION
FACULTY SPONSOR AND APPROVAL OF DIVISION REPRESENTATIVE

INSTITUTIONAL INTENT: one (and ONLY one) MUST be checked.

() academic transfer () occupational preparatory () community service
 () academic basic (X) occupational supplementary
 () academic general () occupational "useful"

SPECIAL CLIENTELE TO BE SERVED:

The second year or advanced student in the Energy Management Program.

LISTING: one (and ONLY one) MUST be checked.

AAS distribution () () AAS electives () () AAS electives (X) ()
 (transfer only) yes no (transfer only) yes no (15 credit yes no
 block)

IS THIS COURSE TO BE OFFERED ONE TIME ONLY? () (X)
 yes no

CATALOG DESCRIPTION:

College credit for individual projects or research in energy, especially involving energy management in buildings or in engineered processes, solar, or other renewable energy systems. Example projects might include an installed solar water heating system, an energy conservation and management plan devised and carried out at one's home or place of business, building an energy conserving device. The range of projects is vast, but the project must effect real changes that result in energy savings. Prerequisite: All Energy 100 level courses, faculty sponsor and approval of division chairman approvals.

***COURSE OBJECTIVES** (standards against which student performance will be evaluated):

To give the student an opportunity to actually apply principles and practices in the Energy core classes to actual energy management situations and activities.

To enable the student an opportunity to research energy conservation designs and systems and to monitor the effectiveness of such systems.

***METHODS OF INSTRUCTION:** (includes also special requirements for materials, space, support)

This class will be contracted in nature, meaning that students will work on individual or small group problems to find methods to the solution. Students will be expected to propose an area of study, objectives to be performed throughout the quarter, and obtain approval and guidance on an individual basis from the instructor/faculty sponsor. The faculty and student will set specific times for consultation and feed-back on student's progress.

***EXAMINATIONS** (methods of evaluating student attainment of objectives):

Completion of the problem will constitute both classwork and examination requirements.

Completion of the project, either individual or team, will determine how well the student has grasped the essential elements of various courses in the Energy Management program and how principles learned to actual situations have applied.

***GRADING:**

Letter grade

*DETAILED COURSE OUTLINE:

TEXT: None required

The following brief course syllabus is structured to show the progress from the beginning of the term to its conclusion of an acceptable project:

- #1 Introduction and orientation of the course and it's objectives to the student. Satisfactory completion requirements will be discussed with the student to ensure that the student is aware of what will be required for completion of project.
- #2 By the second class meeting, students will have examined possible projects and selected the appropriate one for study. Further, students will have written out project objectives and determined course of action to accomplish the project tasks.
- #3 Identification and evaluation of problem areas pertinent to each individual project or research is discussed by the student and instructor.
- #4 Resources available to the student are investigated as a guide for completion of the project.
- #5 Throughout the rest of the quarter, the student must demonstrated continuous enthusiasm and interest in the project. This will be accomplished by weekly meetings with the instructor to review progress.

Review of project:

The student must have specific practical and usable results upon completion of the project.

The final written presentation must include the following information for proper evaluation by the instructor:

- A. Project objectives
- B. Problems to be addressed in project
- C. Recommended solutions, if any
- D. Conclusions and comments
- E. Appendices and resources used
- F. Substantiated progress meetings with instructor listed for reference.

*DETAILED COURSE OUTLINE, continued (use additional sheet if necessary):

PROCESS:

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ENERGY MANAGEMENT FULL-TIME EQUIVALENTS

(STAFF AND STUDENTS)

1979-80 (F, W, S)

Fall Quarter 1979

<u>Course #</u>	<u>Course Name</u>	<u># of Students</u>	<u>Credits</u>	<u>FTEF*</u>	<u>FTES*</u>
100	Introduction to Energy	30	5	.33	10.00
130	Solar Energy Concepts	35	3	.20	7.00
		<u>65</u>		<u>.53</u>	<u>17.00</u>

Student/Faculty Ratio - 32.07

Winter Quarter 1980

<u>Course #</u>	<u>Course Name</u>	<u># of Students</u>	<u>Credits</u>	<u>FTEF*</u>	<u>FTES*</u>
140	Renewable Energy Systems	35	3	.20	7.00
150	Practical Thermodynamics*	21	5	.33	7.00
		<u>56</u>		<u>.53</u>	<u>14.00</u>

Student/Faculty Ratio - 26.42

Spring Quarter 1980

<u>Course #</u>	<u>Course Name</u>	<u># of Students</u>	<u>Credits</u>	<u>FTEF*</u>	<u>FTES*</u>
110	Materials and Design in Conservation	37	3	.20	7.40
210	Energy Auditing and Calculations	30	5	.33	10.00
		<u>67</u>		<u>.53</u>	<u>17.40</u>

Student/Faculty Ratio - 32.83

ANNUALIZED STUDENT/FACULTY RATIO - 30.44

DURING THE 1979-80 SCHOOL YEAR (Fall, Winter and Spring quarters), 94 INDIVIDUALS ENROLLED IN ENERGY MANAGEMENT COURSES.

* FTEF - Full-time equivalent faculty

* FTES - Full-time equivalent students

* Practical Thermodynamics - later shown as "Fundamentals of Heat Transfer"

303
268

10/80

ENERGY MANAGEMENT PROGRAM

TENTATIVE COURSE OFFERINGS

1980-81

<u>COURSE NUMBER & TITLE</u>	<u>INSTRUCTOR</u>	<u>CREDITS</u>	<u>DAYS</u>	<u>TIME</u>
<u>Fall Quarter 1980 - begins week of 9/29/80</u>				
100 Introduction to Energy	Lampcov, B.	5	T&R	7:20-09:35 pm
130 Solar Energy Concepts	Eklund, K.	3	W	7:20-10:10 pm
230 Advanced Solar Energy	Lovelace	3	W	7:20-10:10 pm
299 Special projects	Lovelace	5	AsArr	AsArr.
<u>Winter Quarter 1981 - begins week of 1/5/81</u>				
140 Renewable Energy Systems	Lampcov, B.	3	M&W	6:00-07:15 pm
150 Practical Thermodynamics	Lampcov, B.	5	M&W	7:20-09:35 pm
220 Energy Control Devices	Anderson, L.	3	T&R	6:00-07:15 pm
211 Commercial Buildings	Scace, J.	5	T&R	7:20-09:35 pm
299 Special Projects	Lovelace, P.	5	AsArr	AsArr.
<u>Spring Quarter 1981 - begins week of 3/30/81</u>				
110 Materials & Design in Construction	Staff	3	T&R	6:00-07:15 pm
210 Energy Auditing/Calculations	Staff	5	T&R	7:20-09:35 pm
285 Energy Building Codes	Staff	3	W	7:20-10:10 pm
299 Special Projects	Staff	5	AsArr	AsArr.

300

269



Dear Prospective Student:

Thank you for your interest in the Energy Management program. Hopefully, the following information will answer many of your questions about the energy program.

Edmonds Community College is one of the first colleges in Washington to address the issues of energy as it relates to our economy, energy conservation measures, alternative energies and total energy management. Incorporated into the course offerings are classes for the novice interested in learning more about energy and advance courses for students interested in a possible career in the energy field.

The faculty of the Energy Management program consists of experts who are currently working in the energy field. Instructors are chosen who have demonstrated their knowledge and skills in the area of energy and who have a personal commitment to teach others about our energy needs.

To enter the program, students should call the Information Center at 771-1545, or write to Edmonds Community College, 20000 - 68th Ave. W., Lynnwood, WA 98036, and request an appointment time to register. At the time of registration, it is strongly recommended that you speak to the program advisor who can assist you in scheduling your class or classes, and discuss possible prerequisite requirements.

Tuition for Washington resident (people who have lived in Washington for a year or longer) is \$10.20 per credit with a maximum of \$102.00 per quarter. Out-of-state students pay \$39.60 per credit with a maximum of \$396.00 per quarter. To complete the program as a full-time student generally takes six to seven quarters.

If you have any further question, please write, or call me at 771-1507.

Sincerely,

Elaine Weitz, Coordinator
Energy Management Program

Enclosures

1a

Edmonds Community College

20000 68TH AVENUE WEST, LYNNWOOD, WASHINGTON 98036, (206) 771-1500

270
310



EDMONDS COMMUNITY COLLEGE

ENERGY MANAGEMENT AS A CAREER

Energy Management is a rapidly developing field with a need for qualified people in all phases of energy conservation, consumption and management. The Technician is employed in any of the following energy fields: energy-related research and development, auditing energy consumption, energy use management of commercial buildings, working for specialized energy conservation firms, energy efficient construction which may include designing and installing solar or other alternative heating systems, distributor for manufacturers selling energy systems.

The responsibilities and functions of such a technician might include: an ability, knowledge and skill to test, operate, maintain, or install/modify equipment used in homes, businesses, institutions, and factories; analyze the production, use or conservation of energy; recommend and follow through on steps required to increase the efficiency in the use of energy. Typically, the technician can apply modern sophisticated testing equipment to systems using combinations of mechanical, electrical, thermal, fluid, and/or optical components in energy research, production, use or conservation. Frequently these systems are controlled by electronic computers or microprocessors. The technician usually works under the direction of an engineer, scientist, or manager, often with a large degree of independence, and often supervises the efforts of skilled workers in accomplishing the tasks necessary to the position.

At this time, Edmonds Community College has been able to categorize four major areas of energy related occupations. With further advancement of technologies, other areas will be defined.

Energy Conservation - Involves the development of a basic knowledge and understanding of the application of energy conservation techniques, competence in determining excess energy usage, and designing conservation strategies to curtail energy consumption. These would include insulation, weatherization, infiltration and equipment utilization for maximum energy efficiency and greatest savings.

Energy Management - Would concentrate on the development and implementation of a systematic energy management process. Areas to be included are energy management procedures, reporting and auditing energy use, and developing operating plans and conservation guidelines. Also included would be the capability to monitor and improve the energy management system on an on-going basis and to assess benefits realized from sound energy management practices.

Page 2
Energy Management as a Career

Solar Technology - Develops a basic understanding of solar energy concepts including solar heating and cooling, an understanding of active and passive solar systems, and the study of various solar system components. The practical aspects would include installation, maintenance, and operation of solar systems with emphasis on system design, economics and cost-benefit analysis.

Alternative Energy - Covers familiarization with various alternate energy sources and the application of these in a practical way. Possible sources to be further studied would include solar, wind, biogas, and water; with emphasis on developing an understanding of the relationship between fossil fuels and alternate energy sources and their potential co-utilization.

Salaries will vary depending upon education and experience background, as well as area of interest, employer (type of business, fringe benefits, etc.), and personal initiative.

Prepared by:

Elaine Weitz, Coordinator
Energy Management Program
Edmonds Community College
(206) 771-1507

7/80

312

272

EMPLOYER SURVEY
ENERGY MANAGEMENT PROGRAM

OCTOBER, 1980

Prepared by:

ENERGY MANAGEMENT DEPARTMENT
VOCATIONAL EDUCATION
EDMONDS COMMUNITY COLLEGE
20000 - 68TH WEST
LYNNWOOD, WASHINGTON 98036

ENERGY MANAGEMENT EMPLOYER SURVEY

The attached survey was sent to 235 firms in the Greater Seattle - Snohomish County area. The addresses were secured from the Associated General Contractors/Northwest Construction Council membership roster, the Snohomish County Chamber of Commerce mailing list, and the Seattle Master Builders Association and included representatives from the following : mechanical contractors, architects, engineers, governmental agencies, hospitals, insulation contracting firms, manufacturers, utilities, general contractors and apartment/building managers.

The survey was completed in October, 1980. Of the 235 mailed, 12 were returned as not deliverable. 54 questionnaires were returned -- 22.98% of those mailed.

The following are the results of that survey.

ENERGY EDUCATION SURVEY

COMPILED OCTOBER, 1980

A. COMPANY INFORMATION

1. Name of company Tally Sheet Phone No. () _____
2. Mailing address _____ ZIP _____

3. Person completing this form:
NAME _____
TITLE _____

B. COMPANY CHARACTERISTICS

1. Current number of employees _____
2. Indicate classification of your business.
Industrial 12 Commercial 9 Contractor 8
Government 6 Education 3 Professional 16
Other 13 Specify _____
3. Principle activity, major product or service of your business.

C. DESCRIPTIVE INFORMATION

We have categorized four major areas of Energy Education as described below.
Please consider each and evaluate as directed below.

Definitions:

1. Energy Conservation Program: Involves the development of a basic knowledge and understanding of the application of energy conservation techniques, competence in determining excess energy usage, and designing conservation strategies to curtail energy consumption. These would include insulation, weatherization, infiltration and equipment utilization for maximum energy efficiency and greatest savings.
2. Energy Management Program: Would concentrate on the development and implementation of a systematic energy management process. Areas to be included are energy management procedures, reporting and auditing energy use, and developing operating plans and conservation guidelines. Also included would be the capability to monitor and improve the energy management system on an on-going basis and to assess benefits realized from sound energy management practices.

3. Solar Technology Program: Develops a basic understanding of solar energy concepts including solar heating and cooling, an understanding of active and passive solar systems, and the study of various solar system components. The practical aspects would include installation, maintenance, and operation of solar systems with emphasis on system design, economics and cost-benefit analysis.
4. Alternate Energy Program: Covers familiarization with various alternate energy sources and the application of these in a practical way. Possible sources to be studied would include solar, wind, biogas, and water; with emphasis on developing an understanding of the relationship between fossil fuels and alternate energy sources and their potential co-utilization.

D. Please mark the appropriate number indicating the extent to which you perceive each defined area of expertise to be important to your organization.

	Essential	Very Important	Moderately Important	Slightly Important	Not Important
1. Energy Conservation	5 33	4 8	3 5	2 1	1 2
2. Energy Management	5 22	4 9	3 5	2 10	1 2
3. Solar Technology	5 17	4 5	3 9	2 9	1 7
4. Alternate Energy Sources	5 15	4 7	3 15	2 5	1 6
5. Other: _____	5 2	4 2	3	2	1

E. EMPLOYMENT PATTERNS AND PROJECTIONS

1. Do you presently have any employees involved in any energy related positions?
 → YES **32** NO **14** If yes, please indicate position title and briefly describe the position. _____

2. Indicate number of employees currently employed in each area and the educational background of such employees.

	# of employees w/ Graduate Degree	# of employees w/ Bachelors Degree	# of employees w/ Less than Bachelors Degree	# of employees w/ Experience only	Estimated entry salary level/range
Energy Conservation	18	41	30	11	
Energy Management	29	178	23	62	
Solar	10	30	11	5	
Alternate Energy	12	25	8	3	
Other	9	37	17	6	

3. Are you currently considering employing any individuals in energy related position (for the first time or in addition to those cited above)? YES 13 ←
 → NO 34 If yes, please indicate position title(s) and give a brief job description.

4. If you perceive a need to hire employees in any of the energy related areas over the next ten years, please indicate your estimates by area of expertise and estimate period of employment.

	1980	1985	1990
Energy Conservation	7	17	17
Energy Management	32	22	4
Solar	7	52	9
Alternate Energy	6	22	28
Other	2	7	6

5. If no one is currently employed specifically to perform these energy tasks, how are they now managed?

6. What special skills would you seek if you were to actually employ persons in energy related operations?

SKILLS	
ENERGY CONSERVATION	See attached
ENERGY MANAGEMENT	
SOLAR	
ALTERNATE ENERGY	
OTHER	

7. Would you or another from your firm be interested in further advising the college in this program?

19 member of a continuing advisory committee

17 technical consulting only at times

9 assist in actual training/teaching

8. Please indicate the extent to which you are interested in employing a graduate of a two-year energy technology program:

7 very interested

10 no interest presently

15 moderately interested

9 no interest foreseen in the future

7 slightly interested

9. Opinions and suggestions: Please give us any comments you wish to make concerning energy education needs of your organization and the ways in which Edmonds Community College can contribute in helping you meet these needs.

B. COMPANY CHARACTERISTICS

1. Current number of employees _____.

5; 6; 120+; 3; 680; 38; 5; 5; 29; 17; 80; 2; 39,000 Co. wide, 250 in Puget Sound; 80; 3; 2000; 6; 1400; 1-self; 3; 5-6; 85; approx. 25; 6000+; 20; 2; 2+; 1300; 50; 160; 2; 30-34; 250; 160; 1600; 6; 2; 49,000; 60; 0; 1000+; 4; 210; 80; 2; 5; approx. 600.

2. Indicate classification of your business. Other...specify.

Solar Manufacturing
Manufacturer's representative
Public utility
Manufacturer
Land development
Petroleum--all phases
Hospital
Wholesale
Research
Consulting mechanical engineers
Nursing Home
Utility
Private, non-profit corporation
Apartments

3. Principle activity, major product or service of your business.

Solar Greenhouses
Building owner-manager
Building permit application, examination, approval and inspection
Manual representative in plumbing, heating, heat recover insulation and solar equipment.
Electricity
Architects, engineers, planners
Consulting--Energy Management Services
Design of energy efficient, solar powered structures.
Architecture
Sheet metal
SolaRoll--Product for Solar and Radiant Heating
Land development
Petroleum
Temperature control systems, Energy Management Systems
Commercial refrigeration, heating and air conditioning
Engineering and architecture
Patient care
Manufacture solar/ground coupled Heating Systems
Health care
Printing--Newsletter, flyers mainly
Siting, Sales, installation and maintenance of wind energy conversion equipment
Energy efficient systems--retail and installation
Management of forest lands owned by State
Electrical and control power systems
Mechanical contractor engaged in the design and installation of mech. products
Insurance
Research, consulting, sales of publications
Manufacture of aids and devices for disabled persons

3. Continued...

Solar home design and teaching solar home design
Electronics--Federal, Aerospace, trucking industries
Consulting engineers, surveyors and planners
Contract R & B, manufacturing water jet cutting machines
Solar heating manufacture
Design of mechanical systems, studies and reports
Building management and Development
People
Market electricity
Commercial construction
Office Buildings
Wood and paper products
Design and construct passive Solar dwellings
Development and maintenance of transportation facilities
Energy Information
Consulting electrical engineers
Architecture, planning and engineering services
Sales, PR, education and training
Manufacture and marketing Energy management systems
Environmental Control
Rentals
Wholesale Distribution
School District

E. EMPLOYEMENT PATTERS AND PROJECTIONS

1. Do you presently have any employees involved in any energy related positions?
If yes, please indicate position title and briefly describe the position.

Research analyst and resource economist assesses the utilization of wood wastes
in even numbered years.

Shop foremen.

Everyone.

Design draftsmen working on Solar projects. We also use solar consultants in
our classes.

All technical/professional engineering personnel participate in Energy audits/
life cycle cost analyses.

Coordinator of Energy Management Program

Director of Energy Management

Energy Coordinator--6 weatherization crew members.

Employees in Public Transportation and Planning section stress multi-modal
concepts which promote Energy conservation.

Energy management, Sales and Engineers

Entire company

Electrician, plumber

Energy conservation coordination, administer King County Energy Code, advise
on Solar Homes.

Solar and wind management

Sales engineers

All.

Draftsmen -- All are concerned with Energy aspects in designing for clients
efficient and cost/effective structures.

Air conditioning personnel--salesmen

Principal engineer.

All employees are involved in the design, manufacture and/or marketing of de-
centralized energy products.

Project engineer--develops cost effective Energy utilization and management
program and effective utilization of computerized building mgmt. system.

2. Indicate number of employees currently employed in each area and the educational background of such employees. Estimated entry salary level/range.

ENERGY CONSERVATION:

2000 mo.; 12,000 yr.; 15,500; 18-20,000; 27 k/yr; 25,000; 1,000; depends on qualifications; 30-60,000.

ENERGY MANAGEMENT:

20,000; 18-20,000; 25,000; 16,000 yr; 1,200; 1-2000 mo.; Depends on qualifications; 30-60,000.

SOLAR:

13,000-25,000; 12,000 yr.; 17,000 yr; Depends on qualifications.

ALTERNATE ENERGY:

17,000 yr; 900 mo.; Depends on qualifications.

OTHER:

DESIGN: 1200-1500 mo.

ENERGY RELATED SALES: 10% commission

Depends on qualifications.

3. Are you currently considering employing any individuals in energy related position (for the first time or in addition to those cited above)? If yes, please indicate position title(s) and give a brief job description.

Training director, Project Engineer

Will need Solar greenhouse installers--must have carpentry background, have own hand tools, vehicle (prefer truck), be familiar with large power tools (i.e. table saws, planers...), must be capable of independent trouble shooting (creative problem solver)

Plane examiner for Energy Code to determine compliance with code and to answer related questions

Design techniques in mechanical and electrical design departments.

Energy management.

Senior experienced manager to supervise production operations, sales engineer with knowledge of Solar and heat pump techniques.

Sales

Research engineers and scientists. Analyses of Industrial processes for Energy Conservation, coal utilization technology

Manager of energy management department.

Energy auditor/office person

5. If no one is currently employed specifically to perform these energy tasks, how are they now managed?

Our employees who work on projects involving Energy are made aware of the need for practicing conservation and choosing energy efficient solutions.

By me--President

By owner/manager working through superintendent.

Employees

They aren't being effectively managed.

Principals in schools, maintenance personnel

We rely on outside assistance of and when needed

By consultants; however, each architect is a graduate from an accredited

Architects school and is taught a great deal in Energy conservation and Solar.

Turn off the lights and turn down the heat.

By the principal engineer.

5. Continued...

Cost of managing energy in managing natural resources minor compared to value of product. More attention given to protection procedures.

Through our existing building staff under my direction or building operations manager.

Employees presently know how to turn off lights and close doors--these are prerequisite skills for employment.

Engineers, facilities personnel.

Entire workload is done by 2 partners at this time.

6. What special skills would you seek if you were to actually employ persons in energy related operations?

ENERGY CONSERVATION:

Reality experience--i.e. what can be done easier for the least cost, building experience.

Good physics background, heat transfer, computer programming, fluid mechanics.

Knowledge of mechanical systems, operational and maintenance procedures, computer applications, automation, communication (oral and written), marketing.

Energy conservation techniques.

Mechanical and/or electrical engineering degree or experience

Need basic science/engineering/economics training and strong interest in energy.

Good Human relations/communication skills

Educational or practical experience.

Education/knowledge--formal or informal ability to work with people.

Heat loss--knowledge on proper balancing of designs, design trade-offs, mechanical systems.

Design skills--practical skills selling techniques.

Basic understanding and knowledge in all areas of energy conservation.

Experienced with HVAC systems, knowledge of computer and simulation techniques.

Heat loss calculations and comparison of systems.

Analyze existing and new operations and adapt our energy management systems to them.

Technician level.

Design, energy auditing, insulation, math, blue print reading.

Electrical engineering background.

Mechanical and electrical background with operational experience in these fields.

ENERGY MANAGEMENT:

Experience and ability to evaluate the effectiveness of conservation.

Good theoretical background--Physics or thermodynamics, knowledge of computer and simulation techniques.

Solar System integration with other conservation and energy systems in the same building.

Math, electrical, Federal and State legislation.

Engineering know-how.

Mechanical and electrical background with operational experience, also a management background.

Systematic energy management process.

Need highly skilled science/engineering and business finance/economics training and highest possible qualifications.

Educational or practical experience.

Knowledge of various HVAC systems and related control mechanisms.

Hands-on equipment skills, ability to work with people.

SOLAR:

Architectural experience, building experience.

Installations

Basic science degree with strong interest and some experience in solar energy

6. SOLAR CONTINUED...

Educational or practical experience.
Architectural designer with passive Solar knowledge.
Passive design, some hybrid.
Design skills.
Technical background to understand different solar systems and how they operate.
Theoretical background--Physics, knowledge of mechanical systems.
Knowledge of all principles and benefits. Also of disadvantages and limitations.
Design, install experience with solar hardware and systems.
Technician level.
Technical knowledge of solar, refrigeration and heat transfer principles.
Knowledge also of materials used in solar refrigeration.
Math, sheet metal, electrical, plumbing, carpentry, refrigeration.

ALTERNATE ENERGY:

Knowledge of wind and Hydro-electric principles and practical (equipment) aspects.
Broad background in mechanical skills and electrical wiring. Education in Physics, static analysis and electronics.
Trade experience, physical science, math, electrical.
Engineering know-how.
Basic science/engineers degree with strong interest and some experience in Solar energy.

OTHER:

Design--Basic skills in Mechanical and electrical engineering and architectural design for buildings with special emphasis on Energy conservation and application of new energy sources.
Energy related sales--marketing, P.R.
Ground source energy.

9. Opinions and suggestions: Please give us any comments you wish to make concerning energy education needs of your organization and the ways in which Edmonds Community College can contribute in helping you meet these needs.

Great need for solar energy.

I need electrical designers and engineers for system design--the energy mgmt. concepts are secondary to our designs.

Since we are located in Everett, we would like to see all these classes given at the Everett Community College.

I am already active in a similar program at Tacoma C.C. I'd be pleased to help all I can, but do not want to drive to Edmonds.

This Nation's "Energy Problem" is economic in nature. High fossil fuel prices in particular strain our economy. Our goal should be to operate existing energy users as efficiently as possible. Large savings are possible by operating building efficiently. We need people that are trained to operate temperature control systems in these buildings and people to design new systems.

The program should be formulated around specific skills tied to fundamental physics. The "management" skills for energy planning would develop with experience. There is a real danger in a program as such to become a "political science" course and as such its payoff to the community will be very limited.

I believe the organizations themselves first need to be educated as to why these people are needed and how they can benefit the particular organization--how would it be cost-effective for the corporation. Excellent idea and program!!! Definitely a future need.

9. Continued...

Develop programs that put people out into practical applications situations-- make employers an offer (free?) they can't refuse. Organize student help for work projects on owner built solar homes (we may be able to help out with this as we work often with owner/builders).

Our business use of energy is at present a very small portion of expenses.

As time goes on, I am sure, as everyone seems to believe, the cost of energy will continue going up (Possibly a self-fulfilling prophesy). I don't believe that our business will grow to the point that it could support such a specialist on the staff. To be sure, I expect shipping costs to increase, as well as other uses of energy that are out of our control. For these factors, our only choice is to increase prices. I don't believe that the private business sector will provide very many job opportunities in the programs you are outlining without governmental involvement and or regulation.

I think there is a great need to educate employees who work for corporations of the need to conserve electrical and other forms of energy at the place where they are employed. While the average person will turn off a light or turn down the thermostat at home because the results can be measured in the pocketbook, the same attitude does not prevail in the workplace. Unnecessary lights are left on and many are prone to complain if the temp. varies much from the 72-74 degree range. The Emergency Building Temperature Restriction plan has helped in this regard in the use of heating and cooling energy. Here in the N.W. we have to work hard to change attitudes that have developed over the years with our cheap and abundant hydro-electric power. In my opinion, the biggest challenge is to alter these attitudes and life styles. Certainly, technical know how is important, but by itself will not solve our energy problems.

We are always interested in helping in the development of professionals who ultimately can become registered engineers in our State. ON the other hand, our interest in developing technicians for installation work is very limited since the trade unions have a strong-hold on all activites. For example, if an employer is interested in sending an employee to a training session at your College it would be necessary for him to pay the employee over \$22.00 an hour during the time spent in the College or he would be in violation of the Union rules.

Another priority is energy related marketing and sales. What's necessary to market and sell renewable energy products? How do we make the consumer aware of such products and what they can actually do. Also, understand concerning state and federal legislation - what roles do they play? What can be done to these agencies to get them more actively involved? No State incentives for Washington State. (other than property tax exemption) Really doesn't apply to my business which already operates out of the first solar home in Edmonds.

I would recommend the program address the area of computerized building managements. This is a fast emerging technology that has been addressed primarily by a few manufacturers.

I would like to see a solar design course set up for engineering systems, and a solar installer's course for mechanics on the proper installation of components for active systems.

If the program is slanted to building design and systems design with an emphasis in energy, we would be extremely interested. If the program is slanted towards building and system operation only, we would have no interest.

Our company is set up similar to other Solar companies we are aware of. The companies' owners handle the actual solar sizing selling, design, etc. What is needed is a pool of competent solar installers. As such, a solar background is a somewhat helpful attribute for our employees, but we don't really need it.

9. continued...

There is a need for individuals who can minimize energy requirements in industrial plants and commercial buildings. These individuals should combine their college training with time as an apprentice with an architect or plant engineer in several different types industries. Metallurgical and paper industries should be stressed.

With more widespread concern with the development and utilization of alternative energy sources, home builders are beginning to express an interest in locating lots suitable for solar housing. This is not only a matter of location, but also of appropriate developmental design so that the homes can be properly oriented. This is the phase of solar energy with which our company is presently involved. We are presently involved in expanding our company, and plan to begin constructing solar houses within 3 years as an additional facet of our business. At that time, we would definitely be interested in hiring an energy technology graduate. John Raby, President of Pyramid Homes, is a professional civil and structural engineer. He has design an easy to install, easy to maintain solar system with a cost recovery time of 13 yrs., and a sun time requirement of only 8 hours per week. It is also relatively inexpensive. We are anxious to try it out!

One of the major problems we have found is basic responsibility of people interested and skilled in alternative energy. Many seem to be irresponsible about scheduling, neatness, quality and esthetics of work completed. Solar energy has a "bad image" problem to overcome, and badly needs people who are both skilled and responsible. In another area, writing-communicating, there are also problems. Many of the people we have hired and then had to let go have seemed to have only about a high-school D+ ability to write and communicate what it is they know to the lay person. The writing of letters to dealers, customers and government officials is an important part of our business. In addition, technical data needs to be clearly presented and user's manuals and service manuals need to be prepared. Good communication/writing skills are badly needed.

7.	<u>Member of Advisory Committee</u>	<u>Technical Consulting</u>	<u>Training/ Teaching</u>
Timothy Hayes, N.W. Sales Mgr. Bio-Energy Systems 244-9082	X	X	
Robert Small, Exec. Dir. Leo A. Daly & Assoc. 682-1571	X	X	
Darryl Bullington, Research Analyst, Wash. Dept. of Ntl. Resources - 352-0625	X		
Patricia Raby, VP Pyramid Homes 771-5226		X	X
Robert Lamson, Pres. Alten NorthWest 329-9692	X	X	
Orlien Becker, Pres. Pacific Technology, Inc. 623-9080	X		
Harold Broomell, E.M. Dept. John Graham & Co. 447-5600	X	X	X
Michael Jahr, E.M. MacDonald-Miller 763-9400	X		
Rollin Francisco, Co-Owner Rainshadow 323-2377		X	X
Ruth Quinton, Energy Coord. Snoh. County Community Action Council - 252-5141	X	X	
R. L. Jamison, Director, E.M. Weyerhaeuser Tacoma 924-2697	X	X	
Jake Marley, Owner Encon Controls, Inc. 454-2925	X		

7. (Continued)

R. M. Gregson, Director, Conservation & Solar Division Seattle City Light - 625-3738	X	X	X
Gretchen Boehrend, Bus. Mgr. Benjamin S. Notkin & Assoc. 682-3611	X	X	
Dr. Samuel Bernstein, Scientist & Mgr. Flow Research Co. 872-8500	X		
Lloyd Nelson, Director-Engineering Reid, Middleton & Assoc. 775-3434		X	
Linda Gritzke, Employment Mgr. Eldec Corp. 743-1313	X		
John D. McCarthy, Ofc. Mgr. Ecotope Group 322-3753			X
Don Purrington, Bldg. Oper. Mgr. Safeco Insurance Co. 545-5649		X	
Harold Lloyd, Pres. Lloyd Controls, Inc. 775-1561		X	
Dave Komaru, Partner Solergy Co. 479-6915		X	X
Ed Kennell, Mgr. Clean Energy Products 633-5505			X
John Sullivan, Director, Bldg. Oper. Providence Medical Center 326-5782	X		
Lloyd Quatier, Principal Lloyd F. Quatier & Assoc. 776-6018	X	X	X
Boyd Holding, Public Affairs Mgr. Chevron, USA 628-5272	X		

7. (Continued)

Thomas Hartman, Mgr. Eng. Services
The Hartman Co.
634-2772

X

X

X

K. J. Barnett, Pres.
K. J. Barnett Co.
325-5633

X

Suzan Myers, Supervisor
Residential Conservation Dept,
Snoh. PUD 258-8212

X

COMPANIES RESPONDING TO
ENERGY SURVEY

Bio-Energy Systems
2300 S. 118th
Seattle, WA 98168

Leo A. Daly and Assoc.
Broadcast House
Third Ave. and Broad St.
Seattle, WA 98121

Northern Sun Solar Greenhouses
21705 Hiway 99
Lynnwood, WA 98036

Wash. Dept. of Nat. Resources
Lands Building
Olympia, WA 98504

Pyramid Homes
19707 44th Ave. W., 201-B
Lynnwood, WA 98036

Alten Northwest
1134 Poplar Pl. S.
Seattle, WA 98144

Thermal Efficiency Inc.
P.O. Box 1869
Seattle, WA 98111

Twin Cedar Estates
4807 200th S.W.
Lynnwood, WA 98036

Larrabee and Assoc.
Box 77046
Seattle, WA 98133

Pacific Technology, Inc.
235 Airport Way
Renton, WA 98055

John Graham and Co.
1110 Third Ave.
Seattle, WA 98101

Gordon and Cross Engineers
260 S. 5th St.
Tacoma, WA 98402

Washington State Energy Office
400 E. Union
Olympia, WA 98504

MacDonald Miller Co.
11063 Pacific Hwy. S.
Seattle, WA 98168

Wash. State Dept. of Transportation
6431 Corson Ave. S.
Seattle, WA 98108

Rainshadow
3237 Eastlake Ave. E.
Seattle, WA 98102

Sno. Co. Community Action Council
2915 Colby Ave.
Everett, WA 98201

Weyerhaeuser
Tacoma, WA 98477

Hoge Properties
1215 Hoge Building
Seattle, WA 98104

Encon Controls Inc.
14320 NE 21st Suite 18
Bellevue, WA 98007

Seattle City Light
1015 3rd Ave.
Seattle, WA 98104

Madison Aldercrest Conv. Home
21400 72nd W.
Edmonds, WA 98020

Unico Properties
3300 Rainier Bank Tower
Seattle, WA 98101

Benjamin S. Notkin and Assoc.
820 John Street
Seattle, WA 98109

Practical Solar Systems, Inc.
7221 S. 180th
Kent, WA 98301

Flow Research Company
21414 68th Ave. S.
Kent, WA 98301

Reid, Middleton and Assoc.
121 5th No.
Edmonds, WA 98020

Eldec Corp.
16700 13th Ave. W.
Lynnwood, WA 98036

Cooperative Design
500 Aurora No. Suite 201
Seattle, WA 98109

Ecotope Group
2332 E. Madison
Seattle, WA 98112

Adaptive Engineering Lab
23819 78th Ave. W.
Edmonds, WA 98020

SafeCo Insurance Co.
The SafeCo Plaza
Seattle, WA 98185

Indoor Climate Control, Inc.
2310 S.W. Spokane St.
Seattle, WA 98106

Lloyd Controls, Inc.
21414 66th Ave. W.
Mountlake Terrace, WA 98043

Solergy Co.
2202 W. 11th Ave.
Mawette, WA 98310

Clean Energy Products
3534 Bagley North
Seattle, WA 98103

Yellowbird Press
12314 Scenic Dr.
Edmonds, WA 98020

Providence Medical Center
500 17th Ave. C-34008
Seattle, WA 98124

Virginia Mason Hospital
925 Seneca
Seattle, WA 98101

Lloyd F. Quatier and Assoc.
P.O. Box 997
Lynnwood, WA 98036

Tyler Refrigeration
1218 E. Cherry St.
Seattle, WA 98122

Johnson Controls, Inc.
430 Yale Ave. N.
Seattle, WA 98109

Bremerton School District
300 N. Montgomery
Bremerton, WA 98310

Chevron, USA
P.O. Box 220
Seattle, WA 98111

West Coast Metal Products, Inc.
7116 220th S.W.
Mountlake Terrace, WA 98043

The Mithun Assoc. P.S.
2000 112th Ave. N.E.
Bellevue, WA 98004

Eureka Design
603 W. Crockett
Seattle, WA 98119

The Hartman Company
1016 N. 36th St.
Seattle, WA 98103

K.J. Barnett Co.
1136 Poplar Pl. South
Seattle, WA 98144

Building and Land Development Division
#450 Administration Building
Seattle, WA 98104

The Central Building
810 32nd Ave. #238
Seattle, WA 98104

Snohomish County PUD
P.O. Box 1107
Everett, WA 98206

Georgia Pacific Corp.
900 S.W. Fifth Ave.
Portland, OR 97204

Sun Power(?)
7211 S. 180th St.
Kent, WA 98301

Northwest Energy Management Education Consortium

BACKGROUND

Early in the seventies, the community colleges in Washington State concluded that they should no longer await developmental actions of other institutions and agencies to provide guidance toward short and long term training needs in this state, the focal hub of Northwest energy pool. The State's vast hydroelectric output and logical terminus for North slope oil and gas shipping illuminate this as an area of multiple energy choices, and consequently an area attracting industrial, residential and commercial growth. Yet, a kindled fear of possible energy diversion coupled with cost effectiveness jitters prompted industry and labor alike to pass questions to vocational directors about the availability of expanded occupational training for existing employees and preparatory training for an emerging, expanding occupation in managing energy.

While this condition may not be that unique in our nation, the community college administrators determined to launch an immediate serious assessment of the situation. The uniqueness of this effort soon became apparent by the dearth of evidence of on-going energy comprehensive study in the nation.

NEMEC

The Northwest Energy Management Education Consortium (NEMEC) was sanctioned by the Vocational Directors Council and coordinated by the staff of the State Board for Community College Education. Edmonds Community College has been an active participant of the NEMEC consortium of 5 community colleges in Washington charged with responsibility to research, develop, and implement an Energy Management training program. Edmonds is joined by other community colleges at Tacoma, Spokane Falls, Lower Columbia and Yakima. Well-qualified expertise and leadership was found at Tacoma Community College to initiate the study by first conducting a state-wide survey for energy management technicians, employment trends and training standards. Specifically, the survey objectives sought to:

- a. Identify the tasks that energy management technicians typically perform;
- b. Identify the types of business and industry concerns that logically employ energy management technicians; and
- c. Identify statewide employment opportunities, including the number of energy management technicians currently employed and projected through 1985.

Concurrently, a second step encouraged others of the 27 community colleges to send qualified professional staff to consort in a study of the problem. The established five college consortium convened regularly and engaged advisors from the trades, industry, government, and, with the consultant services of the State Office on Energy, examined alternative directions, corresponded with and visited other institutions in the nation and heard expert testimony from energy related technologies. A nation-wide search revealed very little organized engagement of educational and industrial representatives in such a cooperative effort toward energy management and conservation technician training curriculum development.

Following a careful analysis of energy conservation practices extant, the consortium proceeded to synthesize some major conceptual elements for inclusion in curriculum construction. In this phase, the consortium and advisory group were aware that three distinct training population targets exist; public consumers, technological consumers and emerging technicians. Public consumers, while primarily being addressed by public information programs, could become interested in and profit from certain of the modules appropriately developed for that level. However, major focus of this work plan would be on those populations from the technologies requiring specialized orientation/upgrading and the new career exploring students from related disciplines seeking career specializations in energy management and conservation. The work plans proposed

accommodate both experimental orientations. The subject is most suitable for two-year colleges to address, and the Northwest Energy Management Education Consortium (NEMEC) is richly qualified from these experiences to pursue it further. We have touched the tip of the iceberg and fully appreciate the greater dimension of the challenge before us.

OTHER NEMEC ACTIVITIES

The work plan also delineates some major application differences of skills--the need for certain curriculum materials that are common to all (core), and some specialized, addressing limited fields of applications. A plan to define a core curriculum was developed by the consortium as well as needs-satisfactions courses for those related to industrial, commercial, residential and transportation fields. Solar energy is submitted also as it represents one of the few source subject common to all applications. Market analysis for nuclear technician training was completed by the consortium and identified for its parochial importance but does not merit enough universal demand at this time.

Funded by the State Board for Community College Education, and with the endorsement of the Community College's Vocational Directors, NEMEC conducted a highly satisfying, two-day State Energy workshop for energy educators in 1978. NEMEC was again authorized to host a state-wide professional development workshop this year for community college instructors on energy at Edmonds. The conference addressed the training needs of college and industry in energy conservation.

This past year, under contract to the Washington State Energy Office, NEMEC successfully developed and completed eighteen energy auditing training sessions throughout Washington for on-line operation and maintenance school and college building personnel and provided them the necessary training and background information needed to successfully conduct energy audits.

Such extensive experiences of involved training as these have readily identified NEMEC community colleges as qualified training institutions in the energy field.

NEMEC GOALS/OBJECTIVES

1980-1981

The following goals/objectives were developed and approved at the Post-Workshop steering committee meeting held on June 5, 1980 and are hereby recommended to the Vocational Directors and State Board for Community College Education for adoption and approval:

1. It was determined that a statewide survey of employment needs for energy management technicians be performed again. In a field as new and emerging as energy, three years have lapsed since the last survey was completed. Many changes have occurred in developing technologies and employment needs.
2. A statewide survey of consumer education needs in energy topics is needed.
3. Based on Resolution #1 from the professional development workshop, NEMEC should sponsor an energy-awareness workshop for Washington community college presidents and the State Board for Community College Education.
4. There is a definite need for colleges to network. Any college activity pertaining to energy; i.e. seminars, courses, etc. should be shared with other NEMEC represented colleges.
5. All college presidents should be encouraged to designate an energy representative to NEMEC. Further, it is intended to have a planning meeting in October with all interested colleges in attendance, for the purpose of establishing a structure of NEMEC and developing long range goals as pertains to energy education.
6. It is recommended that NEMEC expand its interests and concerns to personal and consumer awareness education (WEES programs, short courses, and lecture series to the general public).
7. Testimony should be developed to inform legislative energy committees of our concerns for adult energy education.
8. SBCCE/CVE support is needed for a professional development workshop in 1980-81, as well as sanctioned support for NEMEC activities.

NORTHWEST ENERGY MGMT. EDUCATION CONSORTIUM MEMBERS
1979-1980

Dr. Edwin Hill
c/o Wenatchee Valley College
1300 Fifth Street
Wenatchee, WA 98801
241-2640

Ted Keeler
Yakima Valley Community College
P.O. Box 1647
Yakima, WA 98907
558-2350

Keith Kirkbridge
c/o Spokane Falls Community College
W3410 Fort George Wright Drive
Spokane, WA 99204
545-4406

Ivonna McCabe
c/o Tacoma Community College
5900 South 12th St.
Tacoma, WA 98465
scan 548-5059

Dr. Robert Sarvis
Edmonds Community College
20000 68th Ave. W.
Lynnwood, WA 98036
scan 241-0280, ext. 524

Joel Schaaf
Lower Columbia College
Longview, WA 98632
239-2357

Elaine Weitz
Edmonds Community College
20000 68th Ave. W.
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HIGHER EDUCATION RESOURCES

1. American Association of Community and Junior Colleges (202) 293-7050
James R. Mahoney, Project Director
Energy Communications Center
One Dupont Circle, N.W.
Suite 410
Washington, D.C. 20036
2. National Council for Resource Development (202) 293-7050
Jacqueline E. Woods, Project Director
NCRD
One Dupont Circle, N.W.
Suite 410
Washington, D.C. 20036
3. American Vocational Association (703) 522-6121
Rafael Rermoselle, Project Director
2020 North 14th St.
Arlington, Virginia 22201
4. League for Innovation in the Community College (213) 479-3941
1100 Glendon
Suite 925
Los Angeles, CA 90024
5. Washington State Commission for Vocational Education (206) 753-5662
Building 17, Airdustrial Park, Mail Stop LS-10
Olympia, WA 98504
6. State Board for Community College Education (206) 753-2000
319 East Seventh Avenue
WEA Building
Olympia, WA 98504
7. Northwest Energy Management Education Consortium (NEMEC) (206) 771-1507
c/o Edmonds Community College
20000 68th Ave. W.
Lynnwood, WA 98036

GOVERNMENTAL RESOURCES

1. U. S. Department of Energy (206) 442-1746
Region 10, 19th Floor
915 Second Avenue
Seattle, WA 98174
2. Washginton State Energy Office (206) 754-1379
400 East Union
Olympia, WA 98504
3. Washington State Department of Transportation (206) 764-4148
District Planning Engineer
6431 Corson Avenue South
Seattle, WA 98108
4. Washington Energy Extension Service
c/o Washington State University
Pullman, WA
Attn: Mr. Jim Barron, Director

Satellite Offices in:
Seattle, Spokane and Yakima
5. U.S. Department of Energy (202) 376-1983
Market Development and Training Program
20 Massachusetts Avenue, N.W.
Washington, D.C. 20545
6. U.S. Department of Energy (202) 252-5644
Speakers Bureau
20 Massachusetts Avenue, N.W.
Washington, D.C. 20545
7. U.S. Department of Energy (202) 252-6482
Educational Programs Division
Mail Stop 8G-031
Washington, D.C. 20585
8. U.S. Department of Energy (202) 376-4426
Solar Energy Transfer
600 East Street, N.W.
Washington, D.C. 20585
9. U.S. Department of Energy (617) 661-3500
Northeast Solar Energy Center
70 Memorial Drive
Cambridge, Mass. 02142
10. U.S. Department of Energy (918) 336,2400, Ext. 258
Energy Technology Center
Fuels Data Bank
Bartsville, Oklahoma 74003

11. U. S. Department of Labor (202) 376-7440
Office of Policy Evaluation and Research
Comprehensive Education and Training Act Program
200 Constitution Avenue, N.W.
Washington, D.C. 20910
12. U.S. Department of Agriculture (301) 344-2740
National Program Staff
Agriculture Research Service
Beltsville, Maryland 20705
13. U.S. Department of Commerce (202) 377-4568
Office of Energy Programs
Washington, D.C. 20234
14. U.S. Department of Commerce (301) 921-3235
National Bureau of Standards
Office of Energy Conservation
Institute for Applied Technology
Washington, D.C. 20234
15. U.S. Department of Commerce (202) 277-4637
Economic Development Administration
University Center Programs
Washington, D.C. 20230
16. U.S. Department of Health, Education & Welfare (202) 353-4035
Office of Technical Information
Systems Development Branch
RECON (Remote Control) -- Energy
Washington, D.C. 20545
17. National Technical Information Service (202) 557-4600
Room 620, Department TNP
425 - 13th Street, N.W.
Washington. D.C. 20004

PROFESSIONAL ORGANIZATIONS AND INTEREST GROUPS

1. Western Solar Utilization Network (503) 241-1222
Pioneer Park Building, Suite 800
715 S.W. Morrison
Portland, OR 97205

(One of four regional solar energy centers funded by the U.S. Dept. of Energy which furthers the public awareness and commercialization of solar energy in: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming)
2. The Ecotope Group (206) 322-3753
2332 E. Madison
Seattle, WA 98112

(A non-profit group dedicated to promoting conservation and appropriate technology through research, demonstration, and education)
3. Building Officials and Code Administrators International (BOCA)
1313 East 60th Street
Chicago, Illinois 60637
4. Energy Action Education Foundation
1523 L Street N.W.
Washington, D.C. 20005
5. American Society for Environmental Education
33 Mill Road
Durham, N.H. 03824
6. Environmental Education Group
18014 Sherman Way, No. 168
Reseda, CA 91335
7. ASHRAE
345 E. 47th St.
New York, N.Y. 10017
8. Association of Energy Engineers (404) 874-8188
464 Armour Circle, N.E.
Atlanta, Georgia 30324

Washington Solar Network
9. Citizens for a Solar Washington (206) 622-9334
Box 20123 Broadway Station
Seattle, WA 98102
10. Citizens United for Responsible Energy (CURE) (206) 864-6038
Box 430 (206) 736-9558
Winlock, WA 98596
Steve Olson
11. Clark County Citizens for a Solar Washington (206) 699-2361
Box 5000 (206) 694-0638
Vancouver, WA 98663
Terry Oliver
Bruce Bolme

12. Inland Empire SEA (509) 573-3285
Box 13
Spokane, WA 99210
Jack Clark
13. Kittitas Valley Alternative Energy Association (509) 968-3232
Rt. 2, Box 636 (509) 925-1448
Ellensburg, WA 98926
Bruce Manclark
14. Klickitat Citizens for Energy Awareness (509) 493-3634
Box 1145
White Salmon, WA 98672
Kate Miller
15. Mason County Energy Education Group (206) 426-3537
Box 831
Shelton, WA 98584
Beth Stacy
16. Methow SEA (509) 994-4962
Rt. 2
Twisp, WA 98856
Vicky Welsh
17. Northeast Washington Appropriate & Creative Technology (509) 775-3865
Rt. 1, Box 149
Republic, WA 99166
Mike Nelson
18. Olympic Alternative Center (206) 385-3478
1221 Lawrence St.
Port Townsend, WA 98368
Levi Ross
19. Pend Oreille Center for Appropriate Technology (509) 447-3708
Rt. 2, Box 99E
Newport, WA 99156
Joel Jacobsen
20. Puget Sun (206) 564-5515
8423 S. 19th
Tacoma, WA 98465
Tom Heidelbaugh
21. Ryegrass Energy Resources Group (509) 522-0072
611 E. Rose
Walla Walla, WA 99362
Randy Son
22. Sincere Harborites Allied for Responsible Energy (206) 249-5251
729 E. Pioneer (206) 538-1000
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Maureen Sheimo

23. Snohomish County SEA (206) 568-1240
425 East Union #D
Snohomish, WA 98290
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24. SOLAR Wenatchee (509) 662-6156
620 Lewis Street
Wenatchee, WA 98801
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25. Southern Puget Sound SEA (206) 352-5202
Box 454
Olympia, WA 98507
David Haskell
26. Stevens County Appropriate Technology (509) 684-9616
1069 N. Washington (509) 684-2515
Colville, WA 99114
Jim Gilmore
27. Tri-Cities Solar Energy Society (509) 545-1217
1732 W. Irving (509) 942-0854
Pasco, WA 99301
Rich Mazzuchi
28. Western Washington SEA (206) 622-9334
314 Economy Building
93 Pike Street
Seattle, WA 98101
Sally King
29. Whatcom Solar Association (206) 733-9211
Box 2305
Bellingham, WA 98225
Cameron McRostie
30. Whidbey Island SEA (206) 221-7485
2920 East High Crest Rd. (206) 321-5285
Langley, WA 98260
Jean Tank
31. Yakima SEA (509) 457-5167
8001 Englewood Crest Drive
Yakima, WA 98908
John Shaw

FUNDING SOURCES

1. U.S. Department of Energy (215) 597-3606
Office of Energy Programs
Region III
1421 Cherry Street
Philadelphia, PA 19102
2. U.S. Department of Energy (202) 376-4344
Office of State and Local Programs
Room 4121
20 Massachusetts Ave. N.W.
Washington, D.C. 20545
3. U.S. Department of Energy
Energy Education Programs Division
Mail Stop 8G-031
Washington, D.C. 20585
 - 1) Faculty Development Program (202) 376-9211
 - 2) PREFACE Program (202) 376-9211
 - 3) Laboratory-Cooperative Program (202) 376-9211
 - 4) Special Projects in Energy Education & Training (202) 376-9208
 - 5) Used Energy-Related Laboratory Equipment Program (202) 376-9211
4. Washington State Energy Office (206) 754-1379
400 East Union
Olympia, WA 98504

Other Possible Sources in Washington

Bonneville Power Administration
Weyerhaeuser Corporation
Boeing Commercial Aircraft Company

AUDIOVISUAL RESOURCES

The Federal Government has a National Audiovisual Center which has produced by or for the government under contract.

By writing the Center, a Bibliography List can be obtained on Environment/Energy Conservation Information. These aids can be purchased or rented.

General Services Administration
National Archives and Records Service
National Audiovisual Center
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TK Fermi, Laura
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I5
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M3 ENERGY.
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TK Schmidt, Fred Henry
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HD U.S. Dept. of state
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HD Marshall, George E.
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TK United States. Pacific Northwest
23.7 River Basins Commission.
U57a REVIEW OF POWER PLANNING IN THE
PACIFIC NORTHWEST.

Energy Conservation

TJ Warren, Betty
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P74 ENERGY.

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HD Abelson, Philip H.
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U52 SCHOOL.
E4914

TJ ENERGY PRIMER, SOLAR, WATER, WIND,
163.9 AND BIOFUELS.

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TJ Teller, Edward
163.2 ENERGY FROM HEAVEN AND EARTH:
T4 IN WHICH A STORY IS TOLD ABOUT
ENERGY FROM ITS ORIGINS 15,000,
000,000 YEARS AGO TO PRESENT
ADOLESCENCE...

HD Tuve, George Lewis
9502 ENERGY, ENVIRONMENT, POPULATIONS,
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T89 CRISES.

TJ Wilson, Mitchell A.
147 ENERGY.
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Petroleum Industry and Trade

HD Adelman, Morris Albert
9567 ALASKAN OIL: COSTS & SUPPLY.
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HD Landis, Lincoln
9576 POLITICS & OIL: MOSCOW IN THE
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V52 POWER.

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D6 DOW CHEMICAL COMPANY.
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TJ DiCerto, J.
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D65 OR JUST ANOTHER PROBLEM?

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HD Hayes, Denis
9502 RAYS OF HOPE: THE TRANSITION
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TJ Lovings, Anory
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L678 DURABLE PEACE.

TJ Simon, Andrew L.
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S57
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TH Anderson, Burce N.
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A53 COOLING, & DESIGNING WITH THE SUN.

TH FUNDAMENTALS OF SOLAR HEATING;
7644 CORRESPONDENCE COURSE.
F7
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TH LOW-COST, ENERGY-EFFICIENT SHELTER
4815 FOR THE OWNER & BUILDER.
L68

TJ Mazria, Edward
810 THE PASSIVE SOLAR ENERGY BOOK: A
M32 COMPLETE GUIDE TO PASSIVE SOLAR
1979b HOME, GREENHOUSE, & BUILDING DESIGN.

TH Shurcliff, William A.
7414 SOLAR HEATED BUILDINGS OF NORTH
S48 AMERICA: 120 OUTSTANDING EXAMPLES.

TJ SOLAR AGE CATALOG: A GUIDE TO SOLAR
810 ENERGY KNOWLEDGE & MATERIALS.
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TJ THE SOLAR AGE RESOURCE BOOK.
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TH United States. Scientific Labora-
7413 tory, Los Alamos, N.M. Solar Energy
U54 Group.

1977 PACIFIC REGIONAL SOLAR HEATING
HANDBOOK.

TH Watson, Donald
7413 DESIGNING & BUILDING A
W37 SOLAR HOUSE: YOUR PLACE IN THE
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Windmills

TJ Torrey, Volta
823 WIND-CATCHERS: AMERICAN WINDMILLS
T67 OF YESTERDAY & TOMORROW.

Wood as Fuel

TP Tillman, David A.
324 WOOD AS AN ENERGY RESOURCE.
T54

TH Vivian, John
7437 WOOD HEAT.
V58

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Bulletin of Atomic Scientist	New Republic
Builder	New York Times
Business Week	Newsweek
Changing Times	Popular Electronics
Conservationist	Popular Mechanic
Conservation Report	Popular Science
Energy Consumer	Science
Energy Management	Science Digest
Environment	Science News
Forbes	Scientific American
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Intellect	U.S. News and World Report
Nation	

SUBJECT HEADINGS in Readers' Guide to Periodical Literature & in General Science Index

Atomic Power	Hydroelectric Power	Solar Houses
Atomic Power Plants	Marine Resources	Solar Systems
Coal Supply	Nuclear Fuel	Steam Power Plants
Electric Plants	Petroleum Supply	Tide Power
Electricity Supply	Power Resources	U.S.-Energy, Dept. of
Fuel	Power Resources, Conservation	U.S.-Energy Research &
Fuel Supply	Solar Energy	Development Admin.
Geothermal Resources	Solar Heating	Wind Power
		Windmills